Hugs, Bible Study, and Speakeasies: Designing for Older Adults' Multimodal Connectedness

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ABSTRACT

Older adults can experience significant changes to their social networks as they age, triggering changes in their social connection practices. In this paper, we extend research on older adults' connectedness behaviors using a multimodal connectedness framing—that is, how they engage with others across platforms, devices, and modalities. Using the COVID-19 pandemic as a case study, we investigate how older adults navigate a major change or infrastructural breakdown in their social routines. We conducted a survey with 146 U.S.-based older adults (65+), and follow-up interviews with a subset of 23 survey respondents. Findings revealed the resilience and innovation with which older adults adapted their behaviors across multiple modalities to maintain social relationships and playfully connect with others in person and online. Using these findings, we propose that research on designing for aging extend beyond designing for connection in the smart home; we argue for a design agenda that prioritizes designing for smart relationships with the potential to persist across spaces via multimodal connectedness.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**; **Empirical studies in collaborative and social computing**.

KEYWORDS

Older adults; aging; elderly; mental health; pervasive technology; aging in place.

ACM Reference Format:
Olivia K. Richards, Gabriela Marcu, and Robin N. Brewer. 2021. Hugs, Bible Study, and Speakeasies: Designing for Older Adults' Multimodal Connectedness. In *Designing Interactive Systems Conference 2021 (DIS '21), June 28-July 2, 2021, Virtual Event, USA.* ACM, New York, NY, USA, 17 pages. https://doi.org/10.1145/3461778.3462075

1 INTRODUCTION

Designing for major life changes or disruptions remains a challenge in the HCI and design communities. Researchers have studied how design can be a part of responding to natural disasters, war and political crises, or infrastructural resource failures (e.g. [1, 64, 86]). Such breakdowns of infrastructures will likely require many to reconfigure aspects of their lives. In this paper, we study one infrastructural breakdown that impacted social connectedness and engagement for older adults: the COVID-19 pandemic. Drawing upon aging, connectedness, and infrastructure research, we show how examining *multimodal connectedness* can help designers and researchers to more holistically understand older adult's repair and maintenance behaviors in moments of social infrastructural disruption.

Older adults (ages 65+) experience a range of changes to their routines and social networks as they age. For example, retirement limits contact with work-related peers and friends, yet also allows for more unstructured time to connect with friends and family members. Additionally, younger family members may move out to start their own families. In these cases, older adults may engage more with activities that connect them with other older adults. Much research related to social connectedness and aging emphasizes how meaningful in-person engagement (e.g., volunteerism [59, 96], religious activities [39], exercise [53], social activities [102, 107]) is important for successful aging [30, 35] and older adults' well-being [75]. Many of these opportunities for social connection rely on social infrastructures to provide services (e.g., exercise classes) and maintain social systems (e.g., religious congregations). However, the coronavirus pandemic (COVID-19) has significantly altered how older adults engage with other people [21], with federal and state regulations in the U.S. and globally limiting various social infrastructures and calling for older adults to limit their usual in-person activities. Limiting in-person social interaction, or disruptions to once-active social relationships, can negatively impact older adult's social well-being and quality of life [25, 31, 75]. Limiting physical touch and close contact can also negatively affect older adults' health, as found in studies during the COVID-19 pandemic [97].

During the COVID-19 pandemic, we know that many people have turned more toward technology to create and maintain social relationships [77], yet we let lack detail about how these changes have affected social routines of older adults. Recent reports show a long-term trend of increasing internet, mobile device, and online community usage by adults over the age of 65 [3, 24, 74]. Yet usage is more limited for adults over 75 years of age, with lower levels of education, and lower income [24]. Older adults faced social and digital exclusion due to COVID-19, yet also encouraged those with internet access to learn to develop connections online [84]. These data suggest that an infrastructural breakdown requiring older adults to rely more on technology for their social routines may cause challenges, but much remains unknown about their shifting connectedness practices.

DIS '21, June 28-July 2, 2021, Virtual Event, USA

ACM ISBN 978-1-4503-8476-6/21/06…$15.00
https://doi.org/10.1145/3461778.3462075

Researchers within HCI and DIS communities have designed, developed, and evaluated technologies to facilitate a sense of social connectedness among older adults, and across older and younger generations [27, 28, 56, 69, 76]. Yet, each of these technologies were intended either to supplement in-person interactions with other people or non-human agents. Moreover, this work tends to focus on perceptions of a singular artifact. We argue for the value of studying how older adults engage with others via a range of digital and non-digital tools and mediums—thus we focus on their practices of *multimodal connectedness*. Prior work suggests technology non-use among older adults is not solely due to lack of knowledge, skill, or access, but can be due to technology not aligning with values for communication [26, 52, 98, 104]. In this paper, we explore how COVID-19 affected technology use for a range of older adults, to understand and inform design for their changing digital social routines amidst an infrastructural breakdown. We build on design, aging, and digital social connectedness research by describing older adults' values when in-person connection is not feasible, and how they re-imagine and reconfigure social activities via multimodal connectedness. We use the COVID-19 pandemic as a case study to address the following research questions:

- **RQ1**: How do older adults use technologies for social connection during an infrastructural breakdown?
- **RQ2**: How are older adults' needs for social connection met and/or not met by technology in times of reduced in-person interaction

To address these questions, we used a mixed-methods approach to survey U.S.-based older adults (n = 146) on their experiences while social distancing, and conduct semi-structured follow-up interviews (n = 23) to understand technology-mediated behaviors. Survey findings show their technology use increased during this time of reduced in-person interaction. From interviews, we find that their needs were not met with regard for intimacy and connection to large groups. We contribute an empirical understanding of how older adults perform infrastructural repair, in times of breakdown, to maintain connections via multimodal connectedness. Specifically, we show how older adults engage in interpersonal connections from a distance in times of reduced in-person interaction. We describe their technology-mediated social connection needs during moments of isolation, values around intimate interactions, feeling up to date with loved ones, and continuity with their communities. We draw on these findings to share design recommendations for technology that supports the values and needs of older adults in social isolation. We contribute insights to the DIS community regarding older adults' unmet needs for intimacy and authenticity with video technology, as well as opportunities for technology-mediated social connection.

2 RELATED WORK

In this section, we first situate our work within literature on aging, isolation, and social connectedness. We then connect themes from this research on aging to infrastructural breakdowns and repair, explaining how we drew on these concepts to study social routines through the COVID-19 pandemic.

2.1 Aging and Social Isolation

Due to typical age-related social changes such as retirement, adult children moving away, and peers with increased health needs, older adults (ages 65+) in the United States may experience higher rates of social isolation and loneliness than other age demographics. A recent poll shows that nearly one in three older adults in the U.S. lack companionship and feel isolated [89]. This data is from 2018 and was collected before the COVID-19 pandemic which has since significantly impacted how older adults connect with other people. A national poll collected since COVID-19 found that more than half of older adults (56%) reported feeling isolated from others compared to 27% in 2018 [62]. This increase in loneliness aligns with state and federal recommendations for people over the age of 65 to significantly limit in-person interactions due to being high-risk for COVID-19 [33, 48]. During the onset of the pandemic (i.e., March-April 2020), Fuller et al. [42] found that older adults reported increases in loneliness and feelings of loss and lack of control, while those who did not experience increased loneliness established new social connections. Other early pandemic research alludes to older adults' resilience and the association between age and relatively greater emotional well-being [20, 23]. Recent literature has explored the risks of social isolation during COVID-19, but from the perspective of providers and organizations supporting older adults [11, 88]. We complement this work by describing the experiences of older adults themselves, and focusing on technology and social interaction in their everyday lives rather than providers or telehealth stakeholders. Also, our study contributes a direct contrast to reports of older adults' COVID experiences, which focus on loneliness and social isolation. We show that the narratives of older adults demonstrate a desire for and acts of connectedness, aligning with a narrative of resilience.

As prior work has established a negative relationship between social isolation and health [45, 66], restrictions on older adults' in-person social encounters could increase health risks. Prior to the pandemic, researchers have studied how to reduce social isolation among older adults by studying how in-person activities such as volunteering and group activities, [30, 35, 39, 59, 96] and technology interventions can be used to facilitate social connectedness [29, 32, 73]. However, because of state and federal regulations in the U.S. that strongly advise against in-person forms of engagement, it remains increasingly important to understand how technology can better support social connectedness amongst aging communities.

2.2 Digital Social Connectedness with Older Adults

As older adults continue to increase their technology use [3, 24], HCI researchers have studied their patterns of digital engagement and connectedness with people inside and outside of the home. In their synthesis of research on digital inequalities among older adults, Francis et al. argue that more research is needed on technology convergence and multimodal connectedness—that is, how older adults navigate synchronous and asynchronous communication, and use multiple communication channels for distanced interactions [41]. Our study focused on older adult's expanded modes of communication as necessitated by the COVID-19 pandemic.

A significant line of work focuses on interpersonal communication, developing systems to promote intergenerational connectedness with grandchildren and adult children (e.g., [100, 101]). However, older adults' concerns about disrupting family members leads to more conscious communication efforts, often with older adults adjusting to routines and technology practices of younger family members [61, 67, 95]. These practices include adapting new hardware or software to facilitate connectedness with younger members of their social networks. Some researchers have studied video-chat and video sharing technologies to support distributed synchronous and asynchronous forms of communication [2, 40]. Shared tabletop systems have been used to provide co-located connectedness between older and younger family members [6, 106]. Researchers have also designed ambient displays to promote awareness of older adults' activities amongst family members [27, 28, 34, 69, 76], and sometimes with peers [7, 50]. Cues such as voice and photos make these rich forms of communication.

More recent approaches to age-related social engagement and connectedness have explored the role of augmented objects, wearables technologies, and social robots. Researchers have prototyped and evaluated augmented objects such as plants, photo frames, windows, clocks, and music boxes to connect older adults with family [5, 7, 18, 50, 60, 69, 80]. Similarly, it becomes difficult to replicate intimate notions of touch with objects. As such, researchers such as Angelini et al. have investigated how wearables like Hugginess can send information through conductive fabric about one's desire for physical touch [4].

One component of connectedness is a sense of companionship. Social robotics researchers have studied how robots can be designed to provide companionship to older adults and be used as a tool for "successful aging" [58]. For example, the Huggable robotic bear [92] and Paro robotic seal [82] have been posited as approaches to improve older adult's emotional well-being. Hutson et al. study of older adults' perceptions towards social robots show that people see potential for these technologies to engage people who are alone in conversation in "intellectual stimulation" [47]. One critique of research at the intersection of robotics and aging is that there has been a medicalized perspective on robotics as surveillance tools that promote ageism rather than reinforce older adults' values of autonomy, independence, and resiliency [58, 108]. In this paper, we explore how older adults align their technology practices motivated by COVID-19 to support these values.

2.3 Infrastructural Breakdowns and COVID-19

The COVID-19 pandemic disrupted (and continues to disrupt) social routines for people of all ages around the world. Drawing upon infrastructure literature, we find that these disruptions or infrastructural breakdowns are both ordinary and extraordinary, occurring in moments of crisis and natural disaster (e.g., [38]) or as expected components of societal functioning (e.g., [85, 86]). In the design and computing communities, discussions surrounding infrastructure have shifted from being solely about physical and organizational infrastructures that provide access to public services (e.g., electricity or water companies) to also including social and human-centered forms of infrastructure (e.g., workplace relationships) [57, 86]. One similarity across varying discipline-specific conceptualizations of infrastructure is that a disruption makes the oft-invisible nature of infrastructural maintenance and repair, visible [91]. In this paper, we explore the maintenance and repair work of older adults as triggered by COVID-19.

To do so, we draw upon infrastructural repair research in design and computing communities. We define infrastructural repair as a behavior to adjust and function with an infrastructural breakdown. When considering short-term breakdowns like natural disasters, repair is seen as a set of behaviors and work to return to normal [13]. However, research on longer-term disruptions with no expectations of normalcy or that shift routines permanently describes such repair as "slippage" or work to adjust to a new normal. With the ongoing COVID-19 pandemic, we see similar themes of limited expected returns to pre-COVID social routines in the near future such as large gatherings or frequent travel. Rather than focusing on what is no longer possible due to COVID-19, we use this paper to explore how one group of people, older adults, are engaging in repair work related to social connectedness as a result of this infrastructural breakdown.

Key research on infrastructural repair often involves tangible forms of repair. In the HCI4D space, literature describes how rural communities, communities with limited access to technology, and communities in the Global South work in "fixing" shops to repair phones and other technologies (e.g., [46]). Also, researchers have studied how makers across age groups engage in DIY work to repair social and cultural disruption. For example, political infrastructural disruption in the 1960s and 1970s spawned a culture of making and DIY amongst older adults in China [93]. In this paper, we extend work on infrastructural breakdowns and repair in the context of aging, contributing empirical data showing how older adults engage in less tangible forms of repair work as affected by an extreme and persistent infrastructural breakdown around the world, COVID-19. Arguably, older adults were one of the groups most affected by this breakdown. Although older adults faced high health risks and were strongly advised to limit in-person interactions, prior work shows that older adults value in-person interactions valuable for communication and connectedness practices like volunteering and leisure activities [51, 55].

3 METHODS

We conducted a two-part study using surveys and interviews to understand how older adults' patterns related to technology use and social routines were affected by social distancing during the COVID-19 pandemic. We engaged older adults using a survey to understand what changes occurred, and through interviews to understand why and how these changes occurred. Our institution's Institutional Review Board classified the study as exempt and approved all study procedures.

3.1 Survey

3.1.1 Data Collection. We designed an online survey to understand older adults' technology use prior to and while social distancing due to COVID-19. We asked questions regarding their in-person vs. remote engagement with others, technology use, new technologies used, and their reasons for trying new things with technology. We refined the survey through pilot testing in the target age group

(adults in the U.S. aged 65+). This pilot test led to the larger, final 40-question survey in which we added questions regarding how they heard about new technologies, as well as how and when they learned how to use them. We deployed the survey online and offered the option to take the survey via phone. On average, the online survey took 14.7 minutes (SD= 9.8 min) and the phone survey took 17.4 minutes (SD=3.5 min) to complete. Participants received $10 for their time.

3.1.2 Recruitment and Participants. To recruit a diverse sample of older adults, we sought participants using three methods. First, we recruited using social media via public posts on Facebook and Twitter. Second, we recruited via email newsletters at local senior centers, and direct emails to members of the Healthier Black Elders Center, recruitment pool of Black older adults interested in research in near Detroit, Michigan in the United States. Third, we engaged older adults using a university participant recruitment pool to further diversify our sample, as we saw under-representation of male voices in the survey.

We cleaned the completed survey responses using both manual inspection and Qualtric's data cleaning tools. We removed responses for one or more of the following reasons: age provided did not match date of birth (DOB); failing attention checks; short survey completion times; straightlining or patterned responses; fake or gibberish text responses.

The survey was completed by 146 older adults between May-July 2020 (ages 65-91; mean= 72 years old; SD= 5.975). Table 1 shows demographic information for survey respondents. With regard to gender, our sample identified as 63% women, 35% men, 1% non-binary, and 1% preferred not to disclose. The larger of number women in our study aligns with U.S. gender ratios, because there are more women than men over the age of 65 [65, 71]. Recruitment from social media, the minority recruitment pool, and the University health research participant pool helped to increased the age and gender diversity. To further diversify our sample, we oversampled Black/African American participants by recruiting from a local minority participant recruitment pool.

3.1.3 Analysis. To analyze our survey data from n = 146 participants, we combined the data from the three samples and ran descriptive statistics to understand technology patterns amongst older adults.

3.2 Interviews

3.2.1 Data Collection. At the conclusion of the survey, we asked participants to indicate their interest in a one hour semi-structured follow-up interview to expand on their survey question responses and gain a better understanding of their experiences while social distancing. Survey participants noted that a one-hour interview on the phone might be too long and draining. Thus, we edited our protocol to ensure that the length of the interview would be 45 minutes or less. We offered participants to take breaks as needed. No participants opted to end early or take a break due to fatigue. During the interviews, we asked questions about their interpersonal connection practices before and after COVID-19, in addition to their needs at this time. We explored how they used technology to support social needs and interpersonal communication while social distancing. Lastly, we engaged participants in future-thinking exercises, asking them to describe how they plan to engage when restrictions on in-person interactions are reduced and any technologies they would need/want to address unmet communication needs. Interviews were conducted by phone and recorded. On average, each interview lasted 35.5 minutes (SD= 8.8 min) and participants received $20 for their time.

3.2.2 Recruitment and Participants. We recruited 23 follow-up interview participants from the pool of survey respondents (age 65-89; mean = 75 years old; SD = 6.162). Interviews were conducted by phone in July 2020. Participants were 60.9% women (39.1% men), and mostly Black or African American (47.8%) and White (43.5%). Table 2 shows demographic and technology use details for each interview participant.

3.2.3 Analysis. All interviews were transcribed in full. The first author engaged in memoing [14], and all authors reviewed, discussed, and coded the interview data and memos using an inductive approach. We discussed insights and memos from each interview on a weekly basis as they were conducted. During initial stages of analysis, we identified common themes across interviews relating to social engagement and use of various technologies for the first time. We analyzed interview data once all interviews were complete. Using thematic analysis, we inductively analyzed data such that older adults' experiences were constructed as "patterns of meaning" [15]. We approached planning, conducting, and analyzing interviews from a positive aging perspective, positioning older adults abilities and strengths in relation to their previous or new technology practices. From the analysis, our primary themes were intimacy and connection, skill development, creativity, technology enforcement, fatigue, and well-being. We further refined these themes through weekly discussions and constant comparison of data across interviews.

3.3 Limitations

This study is based in the United States and may not reflect non-Western cultures. Surveys and interviews began after the COVID-19 pandemic had affected most of the U.S. and social distancing measures were broadly in effect.We did not use a survey panel because we were able to effectively recruit participants online (i.e., Facebook, Twitter, University recruitment pool, emails to a recruitment pool of Black older adults) and offline (i.e., local senior centers newsletters, word of mouth). We did not collect any data prior to the pandemic, and any comparisons of behavior before/during the pandemic represent perceptions and lived experiences of older adults participating in the study. Also, all data on technology use is self-reported and we recognize there is potential for over- or under-reporting.

4 FINDINGS

Survey responses and interviews revealed how older adults' social interactions changed in ways that were interrelated to their technology use, as they performed infrastructural repair to maintain their connections with existing ties and communities, as well as creatively reimagine ways to experience social connection. We found that older adults expanded the modalities through which they

Table 1: Overall Demographics of Survey and Interview Participants

	Survey (n=146)	Interview (n=23)
Gender	Women 92 (63%) Men 52 (35.6%) Non-binary 1 (.7%) Prefer to not disclose 1 (.7%)	Women 14 (60.9%) Men 9 (39.1%)
Age	M=72 SD=5.975	M=75 SD=6.162
Race	White 70 (47.9%) Black or African American 66 (45.2%) Hispanic or Latino 2 (1.4%) Mixed Race/Other 8 (5.5%)	White 10 (43.5%) Black or African American 11 (47.8%) Mixed Race/Other 2 (8.7%)
Location	Midwest 89 (61%) Northeast 27 (18%) South 16 (11%) West 14 (10%)	Midwest 21 (91.3%) Northeast 2 (8.7%)

engaged with others, showing resilience via multimodal connectedness. First, we describe how they increased their use of technology, including making efforts to adopt a range of new mobile devices, software, and social media.

4.1 Understanding the Impact of Infrastructural Changes

All survey respondents reported making an effort to social distance, confirming that they were adhering to recommended guidelines. As a result of all the services that had closed and widespread social distancing, almost all (94.5%) reported they were seeing fewer or the same number of people in person (the remaining 5.5% experienced an increase in the number of people with which they interacted). When asked whether the nature of their interactions had changed, most (71.9%) felt their interactions were different since social distancing. A smaller number reported no change in the way they interacted with others, and interview data indicate these participants may have had limited in-person interactions or experienced social isolation prior to social distancing. Indeed, almost half (46.6%) of survey respondents said that they interacted with few people daily, prior to the pandemic, as shown in Figure 1. Our interview data help to contextualize these changes in quantity and quality of interactions with other people online and offline while social distancing.

4.1.1 Differences in How Infrastructural Breakdowns Were Experienced. Past work has indicated that social isolation affects many older adults [31, 71], and this may have been the case with our participants prior to social distancing. For example, some participants shared that their daily life wasn't very different compared to before the pandemic, and that social distancing due to COVID-19 was *"not much of an issue"* (P19). Social distancing also appeared to be somewhat less challenging for those who had recently retired or had experienced medical challenges that dramatically changed their way of life and their social circles. Prior experience with medical challenges and loss of independence (whether their own or their partner's) had normalized staying home to protect themselves and their family. P18 compared social distancing to his retirement

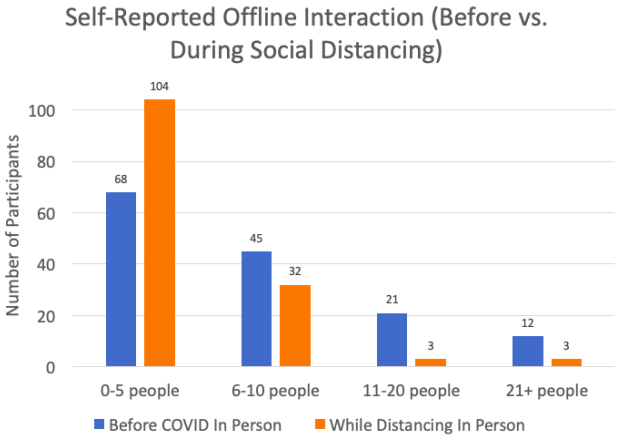

Figure 1: Comparison of participants' self-reported in-person interaction before vs. while social distancing. The biggest change was in interactions with few (0-5) people daily, which increased from 46.6% before COVID-19 to 71.2% during COVID-19.

years prior to the pandemic, which had been an even bigger shift in his social life and *"was a much bigger adjustment than the social distancing"* (P18). This connects to prior work discussing the loss of identity and realization of the aging process [37, 105], yet also speaks to older adults' resilience.

Although the infrastructural changes of COVID-19 reduced social interactions and may have increased isolation, older adults with high levels of activity in their daily lives before social distancing described how COVID-19 helped to slow down their busy routines. Many described such positive effects of social distancing, suggesting that they had been resilient in adapting to the circumstances and/or their needs for social connection may have not been as high as other times in their lives. Several participants expressed a positive outlook toward maintaining some of the changes in their lifestyle, such as spending more time at home and practicing hobbies in the

Table 2: Demographics and Technology Use of Each Interview Participant

PID	Age	Gender	Race	Live In	Live With	Tech Used
1	74	Woman	White	My own home	By myself	Cell phone, Radio, TV
2	79	Woman	Black	My own home	By myself	Cell phone, Computer, TV
3	72	Man	Black	A senior living community	With spouse	Landline phone, Cell phone, Computer, TV
4	76	Woman	Mixed race	My own home	By myself	Landline phone, Cell phone, Computer, Tablet, Radio, TV
5	68	Woman	White	My own home	Spouse	Cell phone, Computer, Tablet, Radio, TV
6	76	Woman	Black	My own home	By myself	Cell phone, Radio, TV
7	72	Woman	White	My own home	Spouse	Cell phone,Computer,Smart speaker
8	88	Woman	White	A senior living community	By myself	Landline phone, Tablet, Radio, TV, eReader
9	91	Woman	Black	My own home	By myself	Landline phone, Cell phone, Computer, Tablet, Radio, TV
10	89	Woman	Black	My own home	By myself	Landline phone, Cell phone
11	77	Woman	Black	My own home	By myself	Landline phone, Cell phone, Computer, Tablet, Radio, TV
12	72	Woman	White	My own home	Spouse	Landline phone, Cell phone, Computer, Radio, eReader
13	68	Woman	Black	My own home	By myself	Landline phone, Cell phone, Computer, Tablet, Radio, TV, eReader
14	72	Woman	Black	My own home	By myself	Landline phone, Cell phone, Computer, Radio, TV
15	76	Woman	Black	My own home	Family member(s)	Landline phone, Cell phone, Computer, Radio, TV, eReader
16	78	Man	Black	My own home	Spouse, family member(s)	Cell phone, Computer, Tablet, TV
17	70	Man	White	My own home	Family member(s)	Cell phone, Computer, Tablet, Radio, TV
18	66	Man	White	My own home	Spouse	Cell phone, Computer, Tablet, Smart Speaker, TV, eReader
19	72	Man	White	My own home	By myself	Cell phone, Computer, Tablet, Radio, TV
20	77	Man	White	My own home	Spouse	Landline phone, Cell phone, Computer, Tablet, Radio, TV
21	69	Man	Lebanese	My own home	Spouse	Cell phone, Computer, Tablet, TV
22	65	Man	White	My own home	Spouse	Cell phone, Computer, Smart Speaker, TV
23	79	Man	Black	My own home	By myself	Cell phone, Computer, Tablet, Radio, TV

future. P15 shared that by stepping back from her job, she realized *"although I was enjoying it, it was too much...in the future, I know that I'll probably still take a day a week, just for me to do nothing. And I hadn't been doing that" (P15).* Similarly, P11 realized that her previous, nonstop lifestyle was tiring and that she *"was out every day for 44 years, so I'm glad to be home ... I enjoy every corner of it."* Similarly, P17 explained how she used to have a very busy schedule, *"but staying home and reading books is actually kind of nice."* These findings suggest that technology could be designed to encourage and support leisure activities, at a time in their lives when older adults may be ready to engage in more meaningful activities outside of work.

4.1.2 Adapting and Maintaining Social Connections. One of the most common ways in which older adults maintained contact with those closest to them was through regular phone calls, and for many, this represented a routine created pre-COVID-19 that they were able to sustain. This was especially true for those who had family that lived farther away, or those who were already living an isolated lifestyle. Thus, they made it a routine to call particular friends regularly, or even more often than before. For example, P19 explained the impact of his routine phone check-ins, saying: *"I've been more active in contacting people for my own purposes to have some interaction and I think it benefits them too... I've always been isolated but suddenly the people outside, it's new to them."* Increased amounts of idle time while distancing at home created opportunities for longer, more frequent, and higher quality conversations over the phone. For example, P2 explained that her family *"didn't call me as often as they are calling me now, in the past, because they were all working on their careers, or getting a degree"*. P10 similarly described more in-depth conversations with friends, which *"have extended from, 'Hey, how are you?', to just some real conversation, about life*

and things that you've experienced all through your life, so you get to know them better and they get to know you better." Therefore, in some ways, participants found it easier to have more meaningful conversations with close ties due to decreased distractions and a more captive audience. We suggest that inform technologies that are designed to encourage more frequent and in-depth conversations (e.g., [17]).

While remote communication seemed to improve for some, older adults were also creative in organizing their own socially-distanced activities to be around others in person—emphasizing the importance of place and proximity to others. For example, since many participants also wanted to keep up with the physical activity they were used to, they arranged outdoor walks with friends during which they would keep a recommended distance (or arrange to talk by phone while they walked separately). Other older adults made use of driveways and doorways to regularly and frequently meet with family and friends while maintaining a safe distance. P20 described how his granddaughter would come to visit in the driveway when she *"buys a new dress and she wants to show it to us...we look out from the door and see her."* P16 indirectly connected with friends by physically exchanging media (i.e., movies, photos, playlists) through flash drives placed in plastic grocery bags at their front doors.

Older adults also conceived of entirely new activities that could allow them to gather together safely. For example, P22 and his friends used an empty barn for what he called a 'speakeasy' (the term used during Prohibition in the U.S. for bars that operated clandestinely, sold alcohol without a license, and filled a void in social interaction): *"I have a friend with a barn. We leave the doors open. We're all pretty aware of the situation. We distance, we've become a little speakeasy, you know, so we can get together but this is 3 or 4 maybe 5 of us."* Through this safe in-person experience, his friends *"bonded more closely"* and he felt he could *"look back at the winter and summer of COVID, you know, in probably a positive light."* Other participants also reflected on how they were spending more time with the people they had nearby, in ways that could strengthen their existing connections with family, friends, and neighbors. For example, P17 used the time at home to connect more with his son who lived next door. They transitioned from two dinners per week to more than five dinners per week, plus breakfasts. As a result, he felt their socially distanced dinners were a way to *"be spending more time together and it's been kind of nice"* (P17). These findings show how remote interactions cannot replicate the experience of being around others, even through brief moments or exchanges. Designers might therefore take inspiration from these creative efforts to design technology to support engagement with older adults nearby (co-located, near co-located) rather than a focus on distributed/remote engagement.

4.1.3 Expanding and Deepening Local Connections. Outside of family members, many older adults said they also strengthened ties with neighbors that they have known for as long as 40 years (P13), because they were watching out for each other during the pandemic. Some also got to know new neighbors and bridge social differences. For example, P15 thought her neighbors were:

> *"Rowdy but I learned that they're just young people... I've gotten to know them a bit... and some of their challenges, just talking. Their young girl just graduated from high school and I just feel for her. I've been able to give her some good advice about goals, and short term and long term goals, and looking back at this, years from now, what does she learn from it and whatever. Just heart-to-heart talk like a grandma to a grandchild."* (P15)

Similarly, P8 became friends outside with a fellow gardener in her building and they exchanged material resources and information about gardening questions. These meaningful connections were shaped from their interest to connect in-person with whoever was around, while social distancing. Being outside where they could see other people was also meaningful for some older adults. P22 and his wife sat on their porch as much as they could, and he described enjoying greater social cohesion in his neighborhood, which he did not think he had ever seen before. Distanced conversations with neighbors or passersby were valuable and enhanced community belonging amongst several participants. While research on older adults often focuses on family and existing relationships, our data extends prior work [17, 79] show how they value new connections, and a sense of local belonging.

4.2 Increasingly Multimodal Connectedness

Most older adults reported that their technology use mostly increased while they were social distancing. This finding is significant in light of the extensive body of literature describing older adults' hesitation to increase their technology use. This literature describes older adults' mistrust in mobile or ubiquitous technology [52], preference to stay away from technology [49], lack of knowledge or interest [26], and lack of perceived value [26, 99].

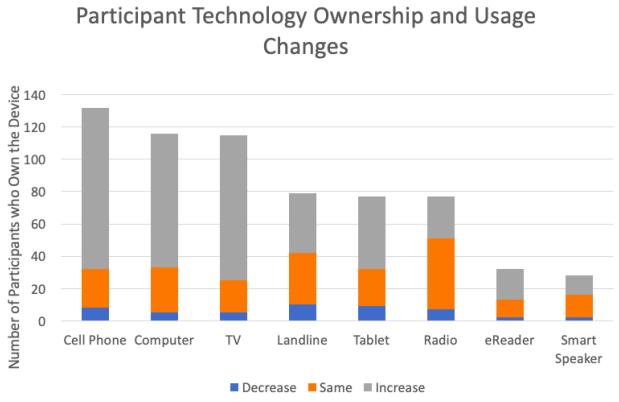

Figure 2: Participants' self-reported technology ownership and usage change compared to prior to COVID-19 (n=146). Most notably, increase in use was reported by 75.8% of cell phone owners, 71.6% of computer owners, and 78.3% of TV owners.

Most survey respondents perceived that their technology use had increased for many of the devices that they owned, including

cell phones, computers, TVs, and tablets. Figure 2 shows the devices that older adults owned and how they perceived that their use of these devices had changed. Our survey also asked older adults what they had been using their devices for, and self-reported data show a range of activities:

- 67.1% talked on the phone more often (using a landline or cell phone)
- 61% sent messages online more often (using Facebook Messenger, email, etc.)
- 64.4% talked using video chat more often (15.8% either did not use or their use had not changed)
- 56.2% sent text messages more often (19.2% either did not notice a change or did not text)

Although phone communication was popular pre-COVID-19, most interviewees said phone calls became longer and more frequent. Such phone communication increased and occurred so frequently that participants described their phone use as *"ridiculous"* (P15), especially in comparison to prior to the pandemic, since *"everyone has idle time"* (P14). Interestingly, technology was used not only to enable direct communication (e.g., phone calls), but also to structure interactions and routines through features such as tasks and contact lists: *"I set up a task [in Microsoft Office] to everyday go to a list of contacts that I have fairly regular communication with... so I've been increasing phone activity because of COVID"* (P19). From these types of interactions, we highlight how technology can play a role in scaffolding routine social interactions.

Before social distancing, survey respondents reported that they infrequently used technology to interact with other people (friends, family, etc.), as shown in Figure 3. Nearly two-thirds (63%) of respondents reported having used technology to interact with few (0-5) people per day, while considerably less (23.3%) used technology to interact with several (6-10) people in a typical day, prior to COVID-19. As in-person interactions decreased, most respondents (75.3%) indicated that their interactions through technology increased while social distancing. A small number of respondents (17.1%) felt that their social interactions through technology stayed the same. We hypothesize that these survey respondents were likely socially isolated prior to the pandemic, had small social circles by choice, or their existing technological practices supported their needs.

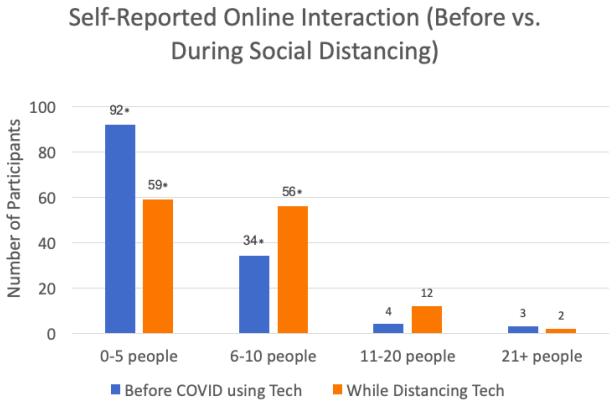

Figure 3: Comparison of participants' self-reported online interaction (using technology) before vs. while social distancing. Interaction with 6-10 people daily using technology increased from 23.3% before COVID to 38.4% during COVID.

Since social distancing, survey respondents reported that they used technology for social interaction more often, and with more people. There was a decrease in the number of respondents who used technology to interact with a few (0-5) people and an increase in daily technology-mediated interactions with several (6-10) or many (10+) people, as shown in Figure 3. The number of survey respondents who reported daily interactions with many (10+) people using technology doubled compared to before social distancing. Thus, survey respondents broadly interacted with more people using technology than they had before.

4.2.1 Adoption and Persistence With Technology Driven by Breakdown. During interviews, older adults explained that they felt forced to use more technology like smartphones, out of necessity to communicate with family and friends. Resistance to adopting new technology was expressed by some participants:

> *"I've been forced... I'll be 73 this month so I'm really forced to have to come into the 21st century and deal with all of this modern equipment junk that I know nothing about or didn't even want to know about. So I'm forced to use it and become acquainted with it, how it functions, how to work it, what it is, and how to adapt and use it so thank goodness I learned how to use a computer."* (P3)

Other participants were not as resistant to technology, rather they had not previously felt as much need to use it because their family lived nearby and they could expect frequent in-person interaction. Before COVID-19, some had not needed to rely on communicating via technology. P15 adapted her technology use to communicate with family in response to the breakdown:

> *"The computer, there was more email and Zoom and that FaceTime stuff, that I would never have used because I didn't think it was all that necessary, because relatives or whatever, most of them are right in the city. It's just a good thing...a good thing."* (P15)

Certainly, adoption was not always easy, and participants also shared the barriers and frustrations they experienced as they interacted with new technologies like smartphones and Zoom. Some participants did not perceive themselves as being tech savvy, but they demonstrated significant persistence and determination. For example, P6 reflected on how she was pushing herself:

> *"I'm learning a lot about this phone, and getting frustrated... I was next to my son who convinced me that I needed to move up, because I was what they call 'behind the times'. But it's getting a little better. I'm challenging myself a little more. I still kinda send people things. I mess up on doing that, but I'm not going to give up... Sometimes it's frustrating, like the other day I was ready to throw [the cell phone] out the window. I was trying to do something, and it brought me to tears."* (P6)

The level of emotion described in relation to learning to use new technologies, and expanding their technology use, suggests the amount of infrastructural repair work by older adults. Support from others and their needs for social connection motivated older adults to persist in this repair work. Several participants indicated that family would visit for technology lessons, but this support was temporary and they were on their own again once these family members left. For example, P11's daughter helped her download Zoom so that she could join a family member's funeral virtually but she *"didn't have the correct passwords and other things to go into it"* (P11). For some, Zoom's usability made it easier to start using on their own; for example, the ease of clicking on the link and automatically joining meetings once Zoom was downloaded. After adopting new technology, some participants taught their friends how to use it, exposing others in their social networks to tools like Zoom or Duo. We therefore found peer support and intergenerational help to be important components of adopting new technologies.

Adoption was also a byproduct of idle time amidst breakdown—both older adults and their social connections had more time, which led to adopting technologies from social media to streaming services. Interviewees described how they began using video communication and new social media platforms such as Snapchat and Instagram, especially at the encouragement of their children and grandchildren, or to feel more engaged with their lives. Of survey respondents who adopted new technologies, 23% indicated that they tried new technology for entertainment purposes and interviewees emphasized that they did so because they had extra time to try things such as Netflix and online games. These data show older adults as not necessarily resistant to adopting new technologies, but leading complex lives that may affect their digital practices.

4.2.2 Using Technologies in New Ways for Connectedness. In contrast to stereotypical perspectives of older adults being hesitant to try new things with technologies that they don't trust [52], understand [26, 49], or perceive as valuable [26, 99], we found that most older adults reported learning new skills and using technology in new ways while social distancing (54.1%). Of the survey respondents who tried new things, most did so to connect with friends and family (73%). For example, P15 had previously used Facebook but explained that he now uses *"Facebook Messenger... calling people on Facebook... I would never do that [before COVID]"*. Others tried new things with technology to engage with telehealth services (27%), entertainment (23%), and online shopping (7%) in their efforts to follow social distancing guidelines.

More than half (53%) of respondents learned new skills from family members or friends, such as how to text, use video calling, play virtual games, and order products online. Interviews further revealed how family and friends supported older adults in learning these new digital skills. As mentioned earlier, some participants emphasized how the pandemic slowed down the rapid pace of life so that they had more time to learn how to do new things, and family or friends had more time to teach them. Several participants relied on their children and grandchildren, such as P2, whose granddaughter *"came home when [her college] closed down [due to COVID-19], so I could call her [for help with technology]."* Widespread breakdown experienced by all therefore meant that others were more available or more willing to help them with repair work. Other participants said they were interested and wanted to learn new things but had not managed to because they did not have family that could teach them, or classes were no longer available as another consequence of breakdown. P3 indicated that he and his wife did not have anyone to learn from and argued that the only alternative to in-person classes was YouTube, where he had sought information on *"everything from putting together a piece of furniture or how to properly use an app"* (P3).

Most older adults said they had tried new things in support of their interpersonal relationships with family and friends, for example by reconnecting on social media, or keeping in touch via messaging (i.e., text, Facebook messenger). Of the technologies that older adults had tried for the first time, video chat and conferencing were some of the most common, with 59% of survey respondents indicating they had tried FaceTime, Duo, Zoom, Skype, Google Meet, etc. Before COVID-19, P17 had heard about Zoom *"in the distance, but I had never used it. Now it's everywhere for everything"* (P17). Out of the interviewees, 17 had tried Zoom for the first time while social distancing, 6 weren't interested in using Zoom, and some didn't want to sit at their computer for long periods of time. No participants had used Zoom before the pandemic, but many had previous experience with FaceTime, Duo, and Skype and increased their use since the start of social distancing.

For many of our participants, church was an important part of their lives that they were missing while social distancing, because it served as a third place—a place outside of work and home where they could socialize and participate [72]. As a result of breakdown, this third place occurred within the home. For participants like P9, the pandemic resulted in the *"first time in my whole life that I've been out of church."* Therefore, repairing church infrastructure seemed to be a key motivating factor for learning how to use Zoom and other video technologies for the first time, especially among participants over the age of 75. Church-based social activities such as religious services, bible study, and support groups were moved online to platforms such as YouTube, Facebook Live, or Zoom. Religious leaders also provided resources and support for accessing services remotely, such as training videos, how-to letters, individual phone calls, and one-on-one support.

4.3 Creativity With, and Limits of, Multimodal Connectedness

Infrastructural repair work by older adults aimed to maintain relationships and significant social connections within both small and large groups. They were creative in combining multiple modalities to meet their needs, including blending physical artifacts with their digital interactions. Overall, they felt that individual and small group interactions with their closest ties could be maintained in some ways (e.g., by phone or online), while larger group dynamics were more difficult to replicate. Instead, many participants chose certain individuals from larger groups with whom to engage, such as closer connections within their church community, by phone or online.

4.3.1 Blending Digital and Physical Modalities. Older adults were actively working to creatively adapt the ways they used technology to engage in social connection, combining modalities and making

adjustments so that technologies would more closely meet their needs. These efforts point to design opportunities for combining modalitiesOne strategy they used to maintain different kinds of relationships was blending virtual connection with in-person activities, and mixing digital with physical artifacts. For example, several older adults found ways to continue playing board games with family and friends, as they had done in person prior to social distancing. They creatively used physical artifacts in their homes like actual game pieces to play board games such as chess and Trivial Pursuit over Zoom. P17 admitted that the process was not efficient, but he appreciated the challenge and having an activity to engage in together to pass the time: *"the game took two or three times as long. Just to figure out, mechanically, how to look at each other's chessboard, but it was fun to try. Since I'm home full time it was a nice way to kill a couple hours."*

Playing games via Zoom was used by some to engage younger family members. For example, participants said they also read books aloud to grandchildren and great-grandchildren while on a Zoom call. One older adult focused entirely on physical artifacts by exchanging paper letters in the mail with his grandchildren. Some older adults were used to exercising with others, and if they didn't feel comfortable enough to physically get together, they were creative by, for example, taking separate routes while using technology to connect: *"I used to meet once a week to go jog with a friend and we don't meet in person anymore, we meet over the phone and walk separately."* (P7)

A couple of participants described using physical artifacts as they participated in church services via video conferencing. For example, they blended the virtual Eucharist[1] experience with physical items such as pouring wine into a big cup, or even drinking a wine cooler. P6 described how she improvised a range of digital and physical artifacts to go along with her bible study groups which have transitioned to Zoom. She received bible study discussion questions via email, read the Bible using a tablet, used a notebook to write down the answers to the questions, and used her smartphone to take a photo of them to send to the bible study facilitator. She also began participating in her brother's bible study, since it had also moved online and become accessible to her for the first time. Based on her participation in three different bible study groups, P6 felt that *"the bible study has been a good experience...We tune in. We can talk. They ask that you're not necessarily interrupting the person that's doing the bible study, but you can stop and ask questions, which is good."* Similarly, P9 began using her tablet more to read the Bible once her bible study group started meeting through Facebook. Therefore, older adults' creativity in blending the digital with the physical helped to enhance not only their interpersonal relationships, but also how they maintained and experienced their spiritual practices.

4.3.2 Technology Enabled Continuity of Relationships and Communities. As a result of their repair work, older adults reported that they were able to maintain continuity in a range of relationships and communities. P15 explained that she was able to communicate via email and Zoom with a group of ladies from church, due to the fortuitous fact that just prior to the pandemic she had brought them to technology classes, they had each purchased a laptop, and they had already been able to learn some of its functionality. P11 described how her weekly engagement with peers from a local women's social society transitioned to one-on-one interactions through Facebook and Facebook Messenger. P10 and P11 also used Facebook to reconnect with people they had not talked with in some time. P15 had connected with friends from church online, and he shared that he received *"much more email from the people in church and it was kind of a big deal"* that people in his church community continued to connect with him, but in a new way.

One of the reasons technology met needs for socializing in small groups was that it helped maintain continuity of close ties and social support. P23 spoke to the benefits of a transition to video conferencing, which enabled a member of his men's group to join even while he was hospitalized in the Intensive Care Unit (ICU). Similarly, many participants appreciated the opportunity to join small groups for virtual celebrations such as a Seder and wedding. P20 explained how FaceTime helped to continue weekly family gatherings, even if the interaction style changed:

> *"With the immediate family we started using FaceTime, although I had used FaceTime before but now doing more of that. Instead of going over and having dinner together Friday night, we have a FaceTime meeting, so we talk back and forth...that's different."* (P20)

Participants also noted unique affordances of engaging with their close ties through technology. For example, they appreciated that with Zoom calls, they had the freedom of leaving a video call with a group, friends, or family when they wished to, without seeming impolite. In other words, relationships could feel more continuous and sustained over time without as much effort needed to considerately end interactions.

4.3.3 Gathering, Acclimating, and Meeting New People Were Harder Online. One of the key ways in which older adults' needs were not met, in spite of their efforts, was in feeling connected to a large group of people and feeling a part of a greater community. Although live-stream church services provided access during breakdown, some older adults felt that these online services were not effective in maintaining a sense of community. P17 felt it was such a different experience that it was not worth participating:

> *"Church services have been a real downer, online. We're actually not even watching much anymore. It's no fault of anyone, other than it's such a hard thing to reproduce online...being in the same room with other people makes all the difference."* (P17)

One aspect of being in the same room in a large group was opportunities to meet new people, which P11 and P10 mentioned missing out on:

> *"I still miss going to my meetings, with the sorority especially, because there are a lot of new people that I want to get to know, that I really didn't have the opportunity to interact with them, because they just made their crossing into the organization, earlier this year. And so, I miss doing that, because they always plan activities around how to acclimate them to being in the organization."* (P10)

[1]The Eucharist, also called Holy Communion, is a blessed sacrament accepted by most Christians. It is a re-enactment of Jesus's Last Supper of bread and wine [10]

None of the participants mentioned having met new people or otherwise expanded their social networks through virtual interactions. Some participants felt it would not be possible to meet new people virtually. Others suggested that their desire to meet new people could be addressed by purposefully orchestrating opportunities, such as virtual meet-and-greets. P15 and P16 each emphasized the potential for meeting new people over video, with P16 acting out how he would greet new people as he explained his enthusiasm for this idea: *"To me, the world is just my living room...bring them on—'hello'...[I want a] meet-and-greet on a daily basis—'hello'."* This finding contrasts with many studies of technology use and aging, which report that older adults are less likely to engage virtually with people they do not know (e.g., [8]) and primarily design technologies for older adults to engage with family members (e.g., [95, 100, 101]). We therefore add to literature that show older adults want to use technology to get to know new people at a distance [17, 19, 103].

4.4 Values when Experiencing Infrastructural Breakdowns

As participants discussed their experiences with technology in the context of infrastructural breakdown, we also identified what they valued, and viewed as important, in these social interactions. These values reveal opportunities to design for multimodal connectedness that can more effectively meet their needs. In this section, we describe how older adults valued intimacy, frequent and authentic updates about loved ones, access and consistent connection to community, and natural and authentic interactions.

4.4.1 Seeking Intimate Interactions. Most older adults missed having intimate interpersonal connection, and interviewees across genders shared that limited or no physical contact was very hard or annoying for them. For example, P14 explained that they struggled *"after 60 plus years of being able to [hug] and now it's dangerous to do so, it's very difficult to remember"* (P14). Some participants decided to see family or friends in person and they were conscious of following all guidelines, but this meant that their gatherings were lacking their usual physical intimacy:

> *"We wear masks, we protect one another, we do social distancing even among ourselves, you know, we've had little backyard get-togethers and everyone wears a mask and we wash hands and very cognizant especially with the children that they are taking care of themselves and that we're taking throughout ourselves around them. So there's not the hugs and so forth that we're usually used to giving."* (P3)

More than half of our interviewees said they especially missed intimate interactions such as hugging, shaking hands, and kissing, and interpersonal experiences like sharing a meal. Some participants, such as P20, highlighted this as one of the most challenging aspects of how he experienced the pandemic:

> *"My biggest regret is that I can't hug my daughter or my grandkids. I haven't in four and half months...since early March...well I wish I could...that's my biggest disappointment. The biggest thing that's missing in my life is that there is no contact. I like to hug, and I miss that."* (P20)

The sense of touch was unable to be replicated through technology, unlike other types of social interactions. This lack was especially hard on those who were grieving. P15 shared that her sibling passed away alone in a nursing home during COVID-19, and like many other families, they were unable to hold a typical funeral due to social distancing measures. In describing this painful experience, P15 noted the value of physical intimacy:

> *"We couldn't really have a regular funeral because they said only two people could be there. So we had a little funeral on FaceTime with other people but it wasn't the same because you can't...hug each other and talk to each other, and have a big meal together. And that was all out, couldn't do that. That was a challenge that I will remember."* (P15)

For many participants who spoke of church as an important community in their lives, physical intimacy was also a challenge. For example, P10 expressed dissatisfaction that she could not embrace the people with whom she worships once church services were moved online: *"I still get the word that way, but it's kind of difficult because you can't go and talk to people, and hug them, and kiss them."* Overall, participants missed this type of intimacy across all of their relationships—family, friends, and community members. Whether there is a generational value that prizes physical touch, or they found it difficult to adjust a lifelong habit, older adults spoke of physical intimacy as one of the biggest changes to their social relationships as a consequence of breakdown.

4.4.2 Staying Updated and Avoiding Isolation. Our interviews revealed that loneliness during breakdown drove participants to strengthen connections and revive old connections—often through new or expanded uses of technology mediums. For instance, P7 organized a Zoom reunion for college friends who hadn't spoken to one another in years, and the group later decided to continue meeting as an anti-racist book club (as anti-racism movements gained momentum during the pandemic). Older adults also noted that they had been intentionally contacting friends and family through social media platforms to stave off feelings of isolation, such as P5: *"I would feel very isolated, if I didn't, at least, talk to them, hear their voice, see their videos or see their Snapchats. I would feel very very isolated. So it's something I look forward to almost every day."*

Social media was also effective for P3, who explained that he had downloaded Instagram *"to see what my kids are saying and doing...a lot of them use Instagram"* (P3). Participants were more likely to have experience with Facebook, while Snapchat and Instagram were newly adopted during the pandemic. Participants described the utility of these newly adopted social media platforms for feeling updated on what is going on in the lives of younger generations. Once they downloaded the apps, they had access to private content that had to do with more personal updates than what might be shared publicly through other social media channels. This type of content helped participants feel more connected with the day-to-day activities of their loved ones. For example, P5 used Facebook less after she downloaded and began using Snapchat as a way to get instant updates on her children and grandchildren:

> *"[While social distancing] they said, 'mama go get on Snapchat.' So, I started using it...I love it. They're instant and I get to see what is going on with the kids. And I think they're just more natural, Snapchat, photos, you get to see what's going on with them, you know, good and bad."* (P5)

P5 perceived Snapchat as a more natural way to communicate than Facebook and videoconferencing because her family members engaged in more authentic behaviors. Social media platforms such as Facebook are used more for professional engagement and attainment, and consequently, it has been noted that self-presentation may limit how people portray their daily lives, with a bias toward positive events and content [9]. Older adults who enjoyed adopting Snapchat and Instagram appreciated that younger generations were so active on these platforms, thereby giving them frequent updates on their lives, and our participants perceived the content as more authentic.

4.4.3 Improved Access and Consistent Connection to Community. Some older adults expressed an appreciation for virtual access to church services, in light of this infrastructural breakdown. This subset of participants was less interested in experiencing the group dynamics of in-person services, or knew others who had previously been unable to physically get to the church and were now able to join the service. A handful of participants also enjoyed no longer having to expend energy on getting ready and physically traveling to church.

Similarly, participants who had previously attended lectures, talks, and conferences continued to participate in these when they moved online. P17 said he did not need to feel a part of an audience during a lecture, and placed higher value on the flexibility of being able to join asynchronous online events when convenient:

> *"You can listen to them when they're live, but then after that they're recorded. You could listen to them at two o'clock in the morning. They don't care. You're not stuck on their schedule...[I like that] because if I fall asleep early, I'm going to wake up around 11 or 12 o'clock and listen to a lecture for 90 minutes and then go back to sleep. I think that's really, really helpful. It doesn't have to be live."* (P17)

However, several older adults argued that being stationary during longer calls was challenging: *"I can't take a break. If I do, I'll miss something"* (P14).

The ability to maintain access and consistency within a community via technology was not an acceptable alternative for all participants. P2 runs a nonprofit senior daycare, which she had been organizing through Zoom meetings, and she found that the technology led to her feeling less involved:

> *"I won't use Zoom [in the future]... I will do this, as long as I have to, but I don't want to see a Zoom once this is over. I just find it impersonal. I don't know, maybe because it's been a little annoying, my becoming acquainted with it. Oftentimes, if you know the screen is on one person but someone on the other side of the room is talking, it's difficult to hear. And, you know, I don't feel as involved. It's not something that I'm fond of. I can adapt to it and use it when I need to. But it's not something that, you know like FaceTime, I like that...maybe because I'm familiar with it...I've been doing that since 2017."* (P2)

Therefore, for some purposes infrastructural repair had been effective or even opened up new forms of access to a community such as church; for others, the repair work was a necessary but undesirable alternative to accessing an important community in their lives.

4.4.4 Authentic, Natural, and Realistic Interactions. Much like the authenticity that participants felt from certain social media content, they also wanted technologies to make their synchronous interactions more natural. For participants like P2, video technologies felt less authentic than in-person communication, particularly in large groups. As such, several participants preferred video calls with individuals instead of groups.

Overall, most older adults viewed video calling as an effective way of communicating with people who are close to them (i.e., friends and family). They anticipated that video calling would be useful in the future when they don't have to practice social distancing so that they can have rich interactions with family or friends at a distance. Of the options available to them, video was the richest medium. They expected to continue use of these technologies, but with less frequency once they are able to return to in-person interactions.

However, many participants mentioned wanting their technology-mediated interactions to feel more natural. For example, some described video communication as impersonal, and said that it needed to be 'more real.' With a background as an engineer, P20 was especially able to articulate how he wanted advanced video conferencing technology to make it feel like he was actually getting together with others:

> *"I'd like to have large...full-size screens so that someone that I'm talking to is right there on a six-foot tall screen, 3 feet away from me and have multiples of those, so I could have multiple people 'in the room' even though they are on a TV screen at the same time and have that all hooked up seamlessly, where I could just say 'come on over' or 'dial up at 5 o'clock' and everybody just pops in like they're holograms. In fact, that would be better than TV screens."* (P20)

When critiquing Zoom, P20 described how it could make others feel more real to him:

> *"See more of the whole person instead of just the face. I could see hand movements or gestures, I would feel like they were close to me as opposed to coming across on an 8x10 iPad or a small fraction of that. It would make it more real to me if you can't be there in person. I would like it as realistically as they were there in person on a hologram."* (P20)

P20 wanted to feel the presence of others not in subtle ways, but in life-sized, authentic representations in order to feel that they were truly together. Overall, most older adults anticipated that video calling will be useful in the future when they do not have to

social distance as the technology expanded their ability to access to various different people, services, and communities from a distance.

5 DISCUSSION

In summary, our findings show the ways in which older adults engaged in repair work due to a significant infrastructural breakdown triggered by the COVID-19 pandemic. We find that requiring older adults to significantly limit in-person interactions led to an increased need for richer, routine forms of communication beyond the phone such as video calls, live streaming platforms, and video sharing online communities to maintain connections with friends, family members, and peers. We describe how they use an ecosystem of communication tools for *multimodal connectedness*, contrasting with prior work that focuses on specific and/or singular devices or communities that older adults use for connecting with peers, friends, and family members. We find that our participants value tools that can support varying levels of intimacy, online and offline, as many older adults also found new ways to maintain ties at a distance by creating their own safe, in-person communities.

Much prior work with older adults focuses on objects that can support such components of healthy aging, focusing on connectedness, intimacy, and mobility with considerable literature on smart homes for aging-in-place. Yet, due to how older adults reconfigured their social routines within, around, and outside of their home spaces, we use this section to describe how designers and researchers can rethink the focus on aging with the home environment, and instead *design for smart relationships* that can persist outside of the home for increased connectedness and intimacy. In what follows we use our findings on older adults' infrastructural maintenance and repair work to extend a call to design for smart relationships, rather than smart homes for older adults, highlighting how designing for relationship development and playfulness are key components of this design agenda.

5.1 Designing for Smart Relationships, Beyond the Smart Home

Our findings show how older adults engaged in connectedness-related repair work online and offline. Online, they learned how to use video technologies including video streaming platforms (e.g., Zoom), video chat tools (e.g., Duo), and new video-related online communities (e.g., TikTok). However, not all repair work was remote. They also engaged in repair work offline by safely reconfiguring their social spaces through speakeasy-reminiscent gatherings, driveway interactions, encouraging letters, or synchronous walks with friends by phone. We connect these careful, safe offline reconfigurations of social interactions to strengths and values within the aging community pre-pandemic in which older adults preferred non-digital connectedness practices. However, much research on intimacy and aging focuses solely on the home environment and designing smart home technologies to support older adults' social connection needs. While the home and residential communities are important spaces of inquiry for aging, our findings show that one's home is not the only place where connectedness can occur. Therefore, we propose that there are opportunities for design to aid in infrastructural repair beyond the home, by *designing for smart relationships*, which we define as technology used to supplement relationship development or maintenance, regardless of location. We note that **designing for smart relationships is about using technology in meaningful ways to augment, amplify, and not replace other forms of social connectedness**. In doing so, we acknowledge neoliberal critiques of applying the term "smart" [44] and position designing for smart relationships as a tool to aid in meaningful connectedness rather than an end in and of itself.

Theories of aging and prior empirical research in aging, design, and HCI communities show how older adults value intimate relationships. While not an exhaustive list, artifacts designed to support values of intimacy include shape-changing interfaces to express emotion [94], smart tea kettles to share messages [16], digital portrait frames and tables [69, 81], gloves and vests that mimic hugs [68, 92], and robotic pets [56]. Spaces designed to support these values focus on smart homes with technologies like fall detection and prevention mechanism and connected objects for remote awareness and connectedness. However, some empirical studies show that older adults find these in-home technologies may be unwelcome forms of surveillance, creepy, not useful, or only of interest due to their novelty [83, 90]. Further, our findings show how older adults sought opportunities to engage outside of their home spaces. Pre-pandemic routines participants enjoyed often included volunteering, non-profit work, or attending religious services. While video platforms allowed for streaming of large events or meetings, video technologies continue to be perceived as less intimate online, as older adults found the lack of small-group conversational interactions to be unappealing and being unable to see one's full body did not feel "real" in one-on-one chat contexts. This made it difficult to strengthen existing relationships, develop new relationships, and engage in activities that were once fun and exciting. From our findings, we propose three opportunities to **design for smart relationships - 1) design for familiar forms of touch, 2) design for relationship development, and 3) design for playfulness**.

5.1.1 Design for Familiar Forms of Touch. Video tools did not work well when older adults craved human touch. Older adult participants struggled with adjusting to technology-mediated interactions where the sense of touch could not be replicated. Indeed, hugging has both mental and physical benefits, which creates a distinct design opportunity to consider how people can convey affection in new ways, and to understand how technology can be used to facilitate intimate social presence, such as using tangible objects. Designers have created artifacts like gloves, vests, and social robots to mimic hugs and human touch for long-distance relationships (e.g., [68, 87]). However, these were either not studied with older adults, or older adults found them to be creepy and not useful in everyday contexts [83]. In contrast, many participants in our study were already or became familiar with video chatting software such as Zoom or FaceTime. Leveraging this existing familiarity with software, and older adults' desire for multimodal connectedness, hardware designers could develop additional wearable or sensing components to fulfill older adult's unmet needs related to touch and "realness". For example, a blanket with sensing technology could connect with the people they talk to on video calls to sense touch

and warmth and display it to the other person. Beyond video technology, wearable technologies can also facilitate social presence at a distance by communicating more human-like cues. For example, activity trackers already have social features such as 'friends' and 'challenges.' Activity trackers or watch bands could encourage more collaborative activities by pulsating to the rhythm of a partner's walking speed during synchronous distributed walks that older adults already engage in by phone. In this sense, activity tracker friends could exercise separately, but still be in sync 'together' through haptic technology. We encourage designers to continue considering ways for **multimodal design to mimic familiar forms of human presence that prioritizes intimacy through everyday technologies**.

5.1.2 Design for New Relationships. Due to the pandemic, many participants voluntarily or felt forced to increasingly turn towards technology to create and maintain social relationships. Our study found that while technology could meet their needs for maintaining their closest connections, one of their primary unmet needs centered around forming new relationships. Many participants reflected on how much they valued meeting new people, helping newcomers acclimate to their community, and feeling connected to various social groups through ad-hoc encounters. Some participants suggested that technology could be used to facilitate new connections, such as through structured meet-and-greets. Prior work also highlights creating new relationships as valuable for older adult bloggers [17] and those on dating sites [63], standing in stark contrast to a significant body of literature within the aging community on maintaining relationships with existing family members and friends. Although participants in our study were aging in place (in their own or family members' homes), establishing new connections are also challenges in long-term care communities where older adults experience social isolation, despite living near other older people [70, 78]. Thus, there remains an open opportunity for **technology to facilitate making new connections with people in older adulthood, especially virtually**, as local community organizations, volunteer events, and senior centers play a role for many older adults. Participants seemed to mostly have experience with the live streaming and/or large group meeting features of video conferencing and chat technologies for sorority meetings, church, or volunteer meetings. However, senior-facing and community organizations could consider leveraging small group capabilities such as Zoom's randomized breakout room feature to match large group attendees with potentially unknown ties, virtually. Similar to smaller support groups by phone, the smaller group size and shared commonality may help to initiate new relationships.

5.1.3 Design for Playfulness. Our data also show ways that older adult participants creatively repurposed technologies originally intended for work and productivity purposes. Participants created new virtual games, started book clubs, and rescheduled family dinners using video conferencing tools. Each of these activities are examples of repurposing for creativity, playfulness, and spontaneity, values that participants found important but described having little time for prior to social distancing. These behaviors contrast with the oft-portrayed narrative of aging and loneliness that was common before and during the pandemic, showing how infrastructural repair and maintenance resulted in innovation and resilience. We draw parallels between this finding and Semaan's work (2019) on long-term disruptions such as war, societal re-entry, and gender transitions, which describes how repair work can lead to increased resilience [85]. Similarly, Graham and Thrift's work on smart city infrastructure (2007) describes how infrastructural breakdowns are "a vital source of variation, improvisation and innovation" [43]. While access can still remain a barrier and technology non-use is a valid choice, our study shows how the circumstances of the COVID-19 pandemic motivated older adults in our study to engage in creative practices to overcome these barriers with and without the use of technology. Similar to themes of strengths-based, assets-based, and positive aging communities, we encourage designers and researchers to **study instances of repair work amongst older communities. Researchers should investigate repair through a lens of innovation** rather than as an expected return to normalcy, or an infrastructural breakdown as something to overcome.

These findings are representative of HCI's third wave, which has shifted from a focus on work and productivity, to studying how people make meaning and share with one anther as they experience "the rest of life" [12]. As the COVID-19 pandemic caused more widespread adoption of technologies among older adults for social connection, more of them joined younger generations in living and socializing through digital technologies, and welcomed the opportunity to slow down and focus less on their own productivity. The result of these changes included new hobbies, new forms of social connection, and newfound appreciation for playful experiences. Moving forward, design for older adults could tap into the playfulness and creativity that resurfaced during this time. Digital tools have increasingly encouraged creativity and self-expression for younger people. Yet, as research in gaming among older adults has shown, self-expression is important across the lifespan [22], and digital games are already used by older adults to connect across generations and meet new people [36]. We therefore encourage more **design of playful technologies that are not targeting productivity or health**, but enabling older adults to engage in meaningful relational experiences and sharing. There are likely to be health benefits of such technologies, but we argue that meaning-making should be the primary focus even when there are therapeutic goals (e.g., art therapy [54]). More research on older adults should focus on designing for enjoyment and playfulness decoupled from other goals.

6 CONCLUSION

To understand older adults' maintenance and repair behaviors as triggered by a recent infrastructural breakdown, COVID-19, we conducted a survey and interviews with older adults about how they connected with others while social distancing. This study contributes an understanding of older adults' multimodal connectedness behaviors within and beyond the home environment. As such, we propose extending a focus on designing for aging and the smart home to designing for smart relationships. Designing for smart relationships may also be useful for other communities experiencing isolation or removed from their typical social networks (e.g., rural communities, people with short-term health conditions,

disabled communities). Further, in building on social connectedness and aging research, we showed how their values and activities for social connection are re-imagined and reconfigured with and without technology in moments of infrastructural breakdown. Understanding such experiences will be useful beyond COVID-19 in the context of other life disruptions that affect older adults' patterns of technology use and limit interpersonal connections. We urge researchers to consider a lens of infrastructural repair and innovation, rather than infrastructural breakdown and deficit when designing new systems to support aging communities.

ACKNOWLEDGMENTS

We would like to thank Nazanin Andalibi, Sam Ankenbaur, Eric Corbett, Tawanna Dillahunt, Cami Goray, Amanda Lazar, Ihudiya Finda Ogburu, and Anne Marie Piper for feedback on drafts of this work. We would also like to thank Ann Dysert for support with data visualization. We are also grateful for being able to partner with the Healthier Black Elders Center and their mission to diversify aging research.

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