Exploring How Persons with Dementia and Care Partners Collaboratively Appropriate Information and Communication Technologies

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Persons with dementia and their care partners have been found to adapt their own technological arrangements using commercially available information and communication technologies (ICTs). Yet, little is known about these processes of technology appropriation and how care practices are impacted. Adopting a relational perspective of care, we longitudinally examined how four family care networks appropriated a new commercial ICT service into their existing technological arrangements and care practices. Cross-case analysis interpreted collaborative appropriation to encompass two interrelated processes of *creating and adapting technological practices* and *negotiating and augmenting care relationships*. Four driving forces were also proposed: *motivating meanings* that actors ascribe to the technology and its use; the *learnability* of the technology and actors' *resourcefulness*; the establishment of *responsive and cooperative care practices*; and the qualities of *empathy and shared power in care relationships*. The importance of technological literacy, learning, meaning-making, and the nature and quality of care relationships are discussed. Future work is urged to employ longitudinal and naturalistic approaches, and focus design efforts on promoting synergistic care relationships and care practices.

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1 INTRODUCTION

As aging and dementia garner increasing design research attention, socio-critical human–computer interaction (HCI) scholars have advocated for more humanistic, experience-centred, and participatory approaches to designing for and with persons with dementia [27, 37, 38, 48, 49]. This shift attempts to redress the "biomedicalized" paradigm [27, 68] from which technology attempts to compensate for the cognitive deficits of persons with dementia [37, 38, 48, 49]. Not only does such a view reduce a person to a narrow set of clinical parameters, it also overlooks design opportunities that may otherwise enrich the lived experiences of persons with dementia [27, 49]. Research involving persons with dementia has underscored that they can and should be involved in the design process, and suggests that their experiences could be enriched with the continuity of meaningful and enjoyable activities [1, 35, 57, 64]; a greater sense of control and security in their everyday activities [7, 41]; and greater social inclusion and social connectedness [2, 6, 36, 38, 42, 64].

Toward enriching experiences for persons with dementia, greater attention to their relations with family care partners has been recommended [1, 25, 28]. Several technological studies have reported differing needs and values between persons with dementia and their care partners, and some have challenged that technology tends to be biased toward the priorities of care partners (e.g., safety, security) [2, 19, 66], thus marginalizing the concerns of persons with dementia themselves. Others have emphasized that care partners influence if and how persons with dementia adopt certain technologies [20, 40, 59, 61], and described how technologies may engender different forms of care efforts by family care partners when supporting older persons [67] or persons with cognitive impairment [28, 58]. The extent to which care partners support technology use may be considered a form of "discretionary effort" [30] that may depend on the nature of the care relationship [22], and require reconciliation with competing roles or other care demands [26, 58]. Caring should be recognized as an interpersonal process through which persons with dementia and care partners continuously balance and negotiate their needs [27, 52]—a shift from the traditional dyadic conceptualization of care [43] as being given by a family member and passively received, for example, by a person with dementia. Taken together, designing technological experiences should value the "ecology of care" around the person with dementia [24] and aim at mutually and synergistically enriching the experiences and relationships for persons with dementia and their care partners.

Within their complex care dynamics, little is known about how persons with dementia and care partners *appropriate* technologies over time—that is, how they adopt and mutually adapt technologies to their practices, and vice versa [10, 15]. Persons with dementia and their care partners have been found to primarily devise "do-it-yourself" solutions [e.g., information and communication technologies (ICTs), adaptations of everyday household products] and, secondarily, privately purchase "off-the-shelf" technologies (e.g., "dementia-friendly" products) [20]. Such trends would

appear to be facilitated by the limited public resources available for assistive technology (AT) provisioning [20] and specialized dementia care services [25, 63, 70]; the stigma that persons with dementia and care partners feel is avoided with the use of everyday mainstream (versus specialized or assistive) products [54, 61]; the greater accessibility of touchscreen devices by persons with dementia [29, 64]; and the need for individualized solutions [1, 2, 22, 54]. While a few longitudinal studies have examined how persons with dementia and care partners adopt ATs [40, 59], less is known about the processes by which mainstream or specialized ICTs are adopted and adapted into everyday practices. Studying these processes can provide greater insight into how technologies are woven into complex dementia care dynamics. Moreover, through a "meta-design" lens, considering appropriation by "users" as part of the design process [17] may highlight new design opportunities not yet considered in the current landscape of ubiquitous technology.

Consequently, our study aimed at describing how persons with dementia (living with mild dementia) and their care partners ("care networks") appropriate commercially available ICTs, and how their appropriation impacts care practices. Theoretically, we pursued these aims from three points of departure (further elaborated in Section 3.1). First, the concept of technology *appropriation* recognizes that users often adopt and adapt technology in unanticipated ways, and evolve their existing practices around the use of new technologies. Secondly, the concept of *bricolage* (adapted from [44] by [22]) highlights how consumers have been found to pragmatically "blend" new and legacy technologies to create new technology arrangements. Thirdly, we assumed a relational perspective of care (advanced by [16, 32, 53]), wherein we conceptualize caring between persons with dementia and their care partners as reciprocal enactments of their social relationships in the forms of nonmedical, emotional, or practical support. From these viewpoints, we expected the persons with dementia to be "active partner[s] in the dementia care experience" [32] and, as such, the technology appropriation processes under study. In this article, we refer to "care partners" as those individuals with whom the persons with dementia sustain a caring relationship (e.g., familial) and, owing in some part to its nature and quality, with those whom persons with dementia have nominated to provide technological support. We use "care network" to refer to a network of relationships between a participating person with dementia and one or more of his/her care partners. Lastly, we use "care practice" to refer to routine behaviors through which care is enacted, and we focus this study on how care practices are impacted through the appropriation process.

2 TECHNOLOGY USE AND DEMENTIA CARE PRACTICES

The HCI literature related to dementia has predominantly focused on the design of bespoke systems in support of persons with dementia and care partners. Most systems (e.g., COGKNOW [13], PAL4 [51]) have been designed with such (or some combination of) functions as delivering schedule reminders, prompting to support everyday self-care or leisure activities, or supporting social communication (e.g., picture or video calling, messaging). Some studies outside HCI, however, have examined the use of ATs (i.e., a wide range of low- to high-tech devices [20] designed to compensate for deficits [59]) and everyday technologies (ETs) (i.e., both new and common analog and digital devices that exist in people's everyday lives [54], e.g., kitchen appliances, telephones) by persons with dementia and their care partners. Fewer studies have investigated the use of commercially available mainstream ICTs (e.g., smartphones, tablets, computers). To note, these technology classifications should be understood to overlap. As examples, ATs can be used in everyday contexts, or can be provisioned through health services or purchased commercially; mainstream ICTs (e.g., cell phones) can be considered a subset of ETs; and ETs may offer "assistive" applications (e.g., smartphone calendar reminders). In this section, we review empirical work that has examined technology use by persons with dementia and care partners and present their key findings as they relate to care practices.

Previous work has suggested that technology use may promote positive experiences for persons with dementia, care partners, and their care relationships. A 9-month evaluation of the commercially available PAL4 system—including an agenda, multimedia albums, and two-way video communication—was demonstrated to support self-care and leisure activities for persons with dementia [51]. Studied extensively for more than 10 years, the CIRCA system has been shown to promote social communication and relationships through its multimedia (photos, videos, music) interaction, by providing more choice and control to persons with dementia in social conversations, and more relaxing and enjoyable social time to care partners with persons with dementia [1, 4]. Over 7-day home trials with 21 care dyads (i.e., persons with early-stage dementia and their care partners) using Apple iPads, Lim et al. [39] demonstrated that iPad use provided persons with dementia with independent leisure time and care partners with temporary respite. Astell et al.'s [2] single-case study over 12 months investigated the impact of mainstream technology use on one person with dementia. The studied person with dementia was able to relearn to use his desktop computer, a laptop, and a smartphone, for such activities as emailing, travel planning, and creating slideshow presentations. Their study highlighted that, with ongoing and individualized support from both the researcher and the wife of the person with dementia, the person with dementia gained a more positive outlook on life and renewed his self-identity through greater self-confidence, independence, control, pleasure, and a sense of participation in society. Positive relational experiences were also found by Lazar et al.'s [36] 6-month case study of one care dyad using a specialized, commercially available technology containing applications for social interaction, exercise, reminiscence, and cognitive stimulation. They found that using the system allowed the daughter to augment her mother's usual care by supporting the daughter's (care partner) discovery of her mother's interests and cognitive limitations; facilitating shared participation and enjoyment of individualized leisure activities (e.g., photo sharing); and cultivating her mother's positive emotions, which altogether supported the quality of their relationship. In another interview study with spouses of persons with dementia, McHugh et al. [46] found that specialized ICTs supported spouses' access to information about dementia, services, and informal resources (e.g., friends); alleviated them from being "tied to the house" if mobile devices were incorporated in their daily care routines; facilitated sustaining social networks of both themselves and persons with dementia; and had the potential of supporting better quality relationships with persons with dementia through supported communication.

While such benefits may be possible, other studies have highlighted the nature and extent of efforts that technology use may require of care partners. In their qualitative interview study, Gibson et al. [20] found that care partners of persons with dementia play pivotal roles in identifying, purchasing, installing, and managing technology, as well as performing the continual "background work" of reminding and reassuring persons with dementia throughout learning and use. Similar findings were reported by Rosenberg & Nygård's [60] interview and observational study of the self-selected everyday technology use (e.g., cell phones, television and DVD players) of persons with dementia, where "significant others" (i.e., adult children, grandchildren, friends, and neighbors) were found to motivate technology use, provide the technology, and provide support through teaching or solving technology-related problems. In another focus group study involving care partners of persons with cognitive impairment (including some who cared for persons with dementia), Piper et al. [58] emphasized that care partners support online activity (e.g., email, messaging, social media) by constantly monitoring, assessing, and adapting their technological support. They delineated four forms of work that care partners may perform: *guiding* describes when care partners functionally assist (i.e., work side-by-side, set up or configure), teach (i.e., cooperate with, learn the technology themselves, and devise strategies to simplify concepts), or mentor (i.e., encourage, motivate) persons with cognitive impairment in their online experiences; *stimulating*

describes how care partners stimulate persons with cognitive impairment through informational, social, and emotional means; *connecting* describes how care partners facilitate social connectedness for persons with cognitive impairment, by setting up video calls, or reading and posting online updates with or on behalf of them; and *protecting* describes how care partners block harmful or distressing content, vet and filter the person's online contacts, mediate their information disclosure, and avoid phishing attempts.

Studies have also indicated that care partners not only support the needs and goals of persons with dementia through technology use, but also promote care partners' own agendas or perspectives. In an interview study with over a 6-month period, Lindqvist et al. [40] found that those care partners who benefitted from persons with dementia using AT (e.g., reduced worrying, saved time) were the most involved in supporting AT use, while care partners who did not directly benefit were less involved. Other studies found that care partners may persuade [20] or force [60] persons with dementia to use technologies in order to facilitate care efforts or activities. Moreover, care partners may exercise their own technological preferences, such as supporting mainstream devices, instead of specialized ATs, with which care partners are more familiar or experienced [20]. In their case study of three persons with dementia and their "significant others" (e.g., family members), Rosenberg & Nygård [59] found that actors held differing viewpoints about the ATs, and, ultimately, the party with decision-making power bore the greatest influence on AT selection and use.

Some scholars have articulated how persons with dementia and care partners balance and negotiate between their differing needs when appropriating technology into their care practices. In their interviews with relatives of persons with dementia that aimed at describing their reflections on different ICT devices (e.g., alarms, tracking devices, modified telephones, and memory aids) used in their daily care of persons with dementia, Olsson et al. [56] described how relatives shifted their perspectives between prioritizing their own and their relatives' (persons with dementia) needs for safety and security. Here, they demonstrated the reciprocal and negotiated natures of decision-making about ICT use and nonuse between stakeholders. Piper et al.'s [58] study also illuminated how online activity is cooperatively negotiated between persons with cognitive impairment and their care partners, often moment-to-moment. Rosenberg et al.'s [61] grounded theory study found that relatives of persons with dementia constructed a "utility perspective" where they were generally ready to support persons with dementia to use technology and to use technology themselves if they believed the technology would keep persons with dementia active in mind and lifestyle; help persons with dementia maintain their desired self-image and avoid stigmatizing them; could be integrated into existing habits; and place minimal demands on persons with dementia and themselves in supporting technology use.

This previous work has underscored the practical and social complexities of appropriating new technologies into dementia care practices. Questions, however, remain about how the collaborative appropriation process unfolds over time within different types of care networks, how appropriation impacts care practices, and how new ICTs are blended with existing products to adapt or create new care practices. The current state of knowledge also suggests investigating these questions in early stages of decline, where persons with dementia retain abilities to learn new technologies and can actively participate in negotiating new care practices with their care partners. Consequently, our study examined multiple cases to describe how different early-stage dementia care networks collaboratively appropriated a commercial ICT product, attempted to situate or adapt it within their existing technological arrangements (i.e., the ETs and ICTs they already use), and how this process impacted their care practices.

3 OUR MULTIPLE-CASE STUDY

3.1 Theoretical Points of Departure

Our theoretical points of departure for this study included the concepts of *appropriation* [10] and *bricolage* ([44], as adapted by [22]), and a relational perspective of care. We describe here our perspective, each concept, and how they interact with one another.

Our study adopted the concept of *appropriation* as the process of "mutual adaptation" where, by adapting and adapting *to* a new technology, users reshape its features and find their own practices reshaped through use [10]. In this study, we focus on collaborative appropriation [50], which examines how the studied care networks participated in new technology appropriation and mutually adapted their care practices to their technology use, and vice versa. We were sensitized to three forms of adaptation that can occur during appropriation (summarized by [50]):

- *Semantic*—changes in the meaning ascribed to technology through in-context use;
- *Behavioral*—new usage patterns that emerge through in-context use; and
- *Technological*—modifications or adaptations of the technology itself.

We were also sensitized to the concept of *bricolage* ([44], as adapted by [22])—the way in which new technologies are combined with existing technologies to devise new technology arrangements. Here the emphasis on the *bricoleur* and the *bricoleur–participant relationship* is consistent with the primary role that care partners have been found to enact in influencing and supporting technology use by persons with dementia [20, 27, 40, 59–61, 66]. Relating this to our concept of appropriation, we assumed that appropriating a new technology may change the meanings ascribed to the new or existing technologies (semantic); displace, shift, or change the use of existing technologies (behavioral); or demand modifications or adaptations to both the new technology and existing technologies (technological). Whether a new technology is adopted at all is also assumed to be influenced by existing technology arrangements. Bricolage also relates to our relational perspective of care in its emphasis on the nature of the caring relationship [22]. Moreover, the pragmatic nature of bricolage resonates with the commonsense and self-initiated ways in which persons with dementia have been found to address challenges to their everyday activities [55], and the way in which dementia care partners intuitively "craft" tools, strategies, and spaces to support care routines and relationships [33].

Our relational perspective of care viewed caring between persons with dementia and their care partners as enactments of their relationships, which vary in nature and quality—for example, by different expressions of reciprocity and interdependence. Importantly, this contrasts the more traditional dyadic conceptualization of caregiving and care-receiving [43]—for example, unidirectionally *from* a family member *to* a person with dementia. We also deviate from the medicalized use of "caring" as support in the management of health and symptoms; rather, we focus on caring in the form of nonmedical social support [11] (i.e., emotional or practical) in the management of everyday life, activities, and social relationships.

We employed these theoretical perspectives and concepts as tentative starting points [12] for an inductive inquiry, and, as such, remained open to evolving concepts throughout data collection and analysis.

3.2 Study Design

This study employed a descriptive multiple-case-study design [65], which allowed us to examine and compare appropriation in four different care networks (listed in Table 1, described in Section 4). This design calls for investigation using a variety of methods, and is appropriate for naturalistic settings wherein the boundaries between phenomenon and context were not clearly delineated

Table 1. Summary of Time and Duration of Data Collection by Case

Case	Informant	Gender	Age	Relationship	Total N hours by informant	Duration of data collection	Total N hours by case
1	Pete	M	79	Person with dementia	10.2	9 months	12.1
	Rebecca	F	52	Adult daughter	1.4		
	Alison*	F	20	Volunteer	0.5		
	Amelia	F	32	Volunteer	2.25		
2	Daniel	M	77	Person with dementia	5.8	9 months	5.8
	Alison*	F	20	Volunteer	1.75		
3	Edwin	M	55	Person with dementia	2.5	2 months	6.3
	Anita	F	54	Wife	5.3		
	Wendy**	F	64	Volunteer	2.5		
4	Patrick	M	71	Person with dementia	7.8	2 months	11.3
	Wendy**	F	64	Former wife	8.25		
	Max	M	37	Adult son	3.25		

Note 1: Informants' real names have been anonymized using the pseudonyms shown in the "Informant" column.
Note 2: Pilot data were collected from Case 1 and Case 2, which account for a longer duration of data collection.
Note 3: The calculation of total N hours by case (rightmost column) count co-participation by multiple informants in one data collection session once.
Note 4: The asterisks indicate the unique informants who provided data across cases.
Note 5: See Section 4 for detailed descriptions of all cases and their informants.

[72]. Consistent with case-study design, this study sought to achieve a deep understanding of each case and create concepts through cross-case analysis [65].

3.3 Study Context

This study was conducted in an urban Canadian city in collaboration with a small technology company (CP) and a local neighborhood organization (NO). One of the NO's mandates is to provide nonmedical services to older adults living in the local neighborhood. The commencement of the study closely aligned with the NO's implementation of a 1-year pilot program ("NO program") that aimed at providing volunteer support to persons with mild cognitive impairment or early Alzheimer's-type dementia who were interested in learning to use the CP's ICT product ("CP system"). This was the first program at the NO that explicitly aimed at supporting persons with cognitive impairment. Given that some of the CP system's features were designed to compensate for cognitive problems (e.g., event and medication reminders) and enable social support by family care partners (e.g., simplified messaging to improve communication and connectedness), the NO program sought to explore and evaluate the use of the CP system by persons with dementia. Accordingly, our research collaboration aimed at supporting this exploration through the use of a qualitative and longitudinal research design. All of our informants were recruited from the pilot program at the NO. Common to ethnographic approaches, the first author ("Amy") played a dual role of researcher and program volunteer, in order to facilitate access to informants and obtain rich data from informants' viewpoints [72]. Her specific role varied between cases and is described in Section 4.

3.4 Technological Context

This study set out to examine the collaborative appropriation of the CP system in combination with other new or existing ICTs (e.g., landline telephones, desktop PCs, laptops, and other mobile

and smart devices) used by the participating persons with dementia and their care partners. The CP system was designed to facilitate social connectedness and aging-in-place for older adults. Although similar to some previously developed systems (e.g., COGKNOW, PAL4, CIRCA), the CP's value proposition of the commercially available CP system is in its promotion of intergenerational connectedness; it offers a simplified way of enabling the intended older adults to access ubiquitous digital communications (e.g., email, messaging applications, video calling, video streaming, and multimedia sharing). As such, CP considers the CP system ideally suited for older adults who wish to maintain social connections and everyday independence, and who are supported by family members—especially adult children—who frequently use digital ICTs, live separately, and desire a better way to support them socially and practically. The design intent of the CP system is to enable these family care partners to digitally communicate with their older adult relatives, who may have difficulty using ICTs (e.g., telephone) and are less or not experienced with ubiquitous digital ICTs (e.g., smartphones); and to better support their relative's everyday quality of life by helping them access social communication, assistive, and leisure functions (e.g., calendar reminders, medication alerts, enjoyment, social stimulation). The CP system consists of a simplified tablet computer designed for technologically novice older adults, accompanied by a web-based portal ("web console") for family care partners to configure and manage older adult's front-end tablet. Using the web console, family care partners can customize on the tablet computer which of the below-listed features will appear on the tablet's home screen. This allows care partners to add new features as they teach the older adult to use them, or remove features that are deemed undesirable or too difficult for the older adult to use.

The CP system's features that were examined in this study were:

- **Call requests**, where the person with dementia can send a request to a selected care partner to call him/her on the tablet;
- **Events** that the care partner can program using the web console, which will deliver date/time-based reminder chimes on the tablet to prompt the person with dementia;
- **Medication alerts** that the care partner can program using the web console, which will deliver successive reminder chimes on the tablet to prompt the person with dementia;
- **Messaging**, which exchanges text-based messages between the person with dementia and care partners; care partners can send and receive messages via SMS, email, or web console, and all messages will be received by the person with dementia *within a single Messaging function on the tablet*;
- **Photos and Videos**, which *automatically save all media attachments from received Messages* (or via web console upload) into a gallery of photos and videos on the tablet for later browsing by the person with dementia;
- **Exercise videos**, which can be uploaded via the web console and viewed by the person with dementia on the tablet;
- **Web links**, which lists on the tablet only those websites that the care partner has added via the web console for the person with dementia; and
- **Video Calling**, where the person with dementia can initiate or receive video calls with/from care partners on the tablet.

To note, during the course of the study, the CP also released a mobile application (on Android and iOS) that delivers the same functionality as the web console. Communications sent from the older adult's tablet could then be received by care partners via the mobile application or, as previously, via text messaging, email, or through the web console.

3.5 Technology Training Context

The NO program's intent was for NO program volunteers to first be trained on the CP system, in order to then set up, customize, and support use by the participating persons with dementia and family care partners. All NO program volunteers (including the first author) participated in one 2-hour group-based training session on the CP system, which was facilitated by one of the CP's founders. Volunteers were also provided hard-copy product reference guides. Subsequent *ad hoc* training and technical support was offered to volunteers by the NO program's staff coordinator and CP founder. Uniquely, Wendy (Case 3 volunteer and Case 4 family care partner) had developed a direct relationship with the CP founder, through which she received direct *ad hoc* technical support. As the informants in each case varied in terms of technological acumen and family care arrangements, the different ways in which the CP system was introduced to the studied persons with dementia and family care partners are described in the case descriptions in Section 4.

3.6 Data Collection

The NO program's staff coordinator ("Coordinator") supported recruitment, which was facilitated by the co-authors' previous research collaboration with the NO. Our inclusion criteria for persons with dementia matched the NO's pilot program criteria: 55 years or older, living in community, and formal diagnoses of mild cognitive impairment or mild dementia. To pursue our research aim, we first recruited those persons with dementia from the NO program who self-reported some degree of family support (e.g., co-residence, frequent assistance). We also recruited into the study those family members whom persons with dementia "nominated" to participate with them. We considered family members "nominated" if they were already co-participating in the NO program and also agreed to participate in the study together, or if the person with dementia invited a specific family member(s) to participate with him, when suggested by the first author. In addition, the NO volunteers who were assigned to support the persons with dementia were also recruited into the study. In total, across 4 cases, we recruited 10 unique informants: 4 persons with dementia, 4 family members, and 3 volunteers. There were two instances of overlap: one informant provided data for two cases, as a former spouse to one person with dementia and as a volunteer to another person with dementia; and one volunteer was assigned to two different persons with dementia. Section 4 describes each case and its informants in further detail.

Pilot data were collected from the first two cases (Pete and Daniel). Pilot data comprised one interview and one participant-observation (i.e., observing through participation in the case by assuming a functional role [72]). Pilot data analysis guided purposive sampling of the second two cases (i.e., Edwin and Patrick) in which family members co-resided or lived locally, actively supported the daily activities and ICT use of the person with dementia, and for which the CP system was successfully appropriated.

Descriptive, primary and secondary data were collected from all cases. Descriptive data included demographic and living and care arrangement information, which are summarized in the "Case Descriptions" (Section 4). In addition, once during the study, each person with dementia and care partner informant responded to a relationship questionnaire (self- or verbally administered), in which they compared the nature of their relationship before and after they had used the studied ICTs for some time (sample questions in Table 2). This questionnaire was developed based on 10 relational maintenance strategies by [8], and informants were encouraged to qualitatively supplement their Likert responses. Given the differences between cases in terms of cognitive functioning and the nature of informants' care relationships, informants were given the options of self-administering the relationship questionnaire (i.e., completing a hard-copy version and returning it to the first author) or verbally responding to the questions (i.e., interview-style) administered

Table 2. Selected Questions from the Relationship Questionnaire that Yielded Salient Qualitative Data to Accompany Likert Ratings (Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree)

Question inquiring about before ICT use (E.g., *"Before you started using the [CP system], how would you rate this statement about you and father?"*)	Question inquiring about before ICT use (E.g., *"After you started using the [CP system], how would you rate this statement about you and father?"*)
We spent time doing activities together.	My everyday technology helps us spend time doing activities together.
We assured each other that our relationship was important.	My everyday technology helps us assure each other that our relationship is important.
We stayed in frequent contact when apart from each other.	My everyday technology helps us stay in frequent contact when apart from one another.

by the first author. These data were intended to guide and contextualize primary data collection insofar as providing descriptions of the nature and quality of informants' care relationships and the influence of and on ICT appropriation.

Primary data comprised semistructured interviews; participant-observations; and one focus group involving most informants (i.e., except Alison and Amelia). Semistructured interviews and participant-observations were conducted by the first author and took place at informants' homes or in the neighborhood (i.e., café or park), at the NO site, or via telephone. Interviews probed further into informants' relationship maintenance questionnaire responses (e.g., *Which aspect or feature of the ICT brought about your mentioned relationship change?*), and inquired about their appropriation as it related to their care relationships and practices (e.g., *Tell me about your experience so far learning and using the CP system*; *How has using it impacted the way that you relate to your [family member]?*). Participant-observations attended to how informants were interacting with the ICTs, their physical contexts (e.g., objects, spaces), and each other (e.g., comfortable versus tense; aligned versus misaligned interests; power dynamics). The focus group presented photos of fictitious characters using the CP system in different use cases and posed questions related to care practices (e.g., *A reminder pops up on Joan's (person with dementia) CP system tablet that reads: "Walk on Saturday with Karen." What does Joan do after she reads this? How does Joan feel about this reminder that Karen programmed for her?*). The focus group was co-facilitated by the first and second authors, and a hired facilitator, and took place at the NO site. The focus group also probed informants to compare their practices using the CP system with practices using existing (e.g., landline telephone) or other new ICTs (e.g., new iPhone), which informants had discussed or demonstrated during previous interviews or participant-observations.

Secondary data included first authors' field notes from informal communications with informants (in-person, telephone, email, text messaging); field notes from her participant-observations during NO volunteer training workshops; and case information contained in NO program documents (e.g., intake forms, volunteers' training diaries). Data were collected between October 2015 and July 2016 and based on informants' availabilities (e.g., health events, adult children's visits) and the NO's program implementation timelines (e.g., recruitment support, focus group scheduling, volunteer turnovers).

Table 1 summarizes the total time and duration of data collection by case.

Researcher's role. Amy Hwang (first author, 33 years old) is a Chinese-Canadian doctoral student in Rehabilitation Science with experience working with older adults and their family members in outpatient and home-based rehabilitation services. In order to gain access to, establish rapport with, and gather rich data from informants, she enacted the role of an NO program volunteer. To

note, between cases, the stage of CP system appropriation, existing ICT arrangements, and technical support provided by care partners vis-à-vis volunteers varied. As such, the way in which the researcher enacted her dual researcher–volunteer roles also varied between cases. This is further described within each case description in Section 4.

3.7 Data Analysis

Pilot data were analyzed by the first author as she completed her second graduate-level course in qualitative research methods, with the support of a seasoned qualitative researcher and gerontology professor. Subsequently, data from all cases were primarily analyzed by the first author (as recommended by [65]), who collected and generated all case data. The first author's analytic memos and categories were scrutinized and critiqued by co-authors, whereupon the first author performed data checks and refined categories. Within-case analysis strived to achieve a particularistic understanding of each case (i.e., gleaned from conducting and transcribing interviews, and generating all field notes). Cross-case analysis was then conducted as each case was analyzed, where analytic categories were generated and iteratively refined [65]. Final interpretations were critiqued by all co-authors.

Within-case analysis. Data analysis was guided by initial coding, focused coding, axial coding, and comparative methods described by [12] and using the NVivo 11 software. Our theoretical framework also informed which categories were deemed salient and prioritized. For example, the three forms of adaptation (i.e., semantic, behavioral, and technical) [50] formed some of our initial categories. Subsequently, the subcategories, "managing multiple devices" and "trial and error troubleshooting," were created under the "technical adaptation" category. Similarly, the subcategories, "enhancing family inclusion" and "relying on others," were created under the "semantic adaptation" category. This process highlighted the most data populated and salient subcategories, for which the first author generated analytic memos, also guided by [12]. As several data overlapped between multiple categories, analytic memos also described their interrelationships. For example, in some cases, the process of persevering with technical adaptations became semantically meaningful for family members in that they enacted care for persons with dementia through supporting their technology use. All analytic memos for each case were then synthesized into detailed case descriptions for each case (Section 4).

Cross-case analysis. This process was guided by Stake's cross-case analysis procedure [65] for maintaining the "case-quintain dialectic," which ensures that cross-case themes are substantiated by within-case themes or categories, which are grounded in case data. After Case 1 and Case 2 were analyzed, substantive subcategories, analytic memos, and full case descriptions were compared. Preliminary cross-case analytic themes were generated with accompanying memos that described the similarities, differences, and nuances between cases. For example, in the analysis of Case 1 and Case 2, the category *disrupting care practices* was generated to capture how technological support from family members disrupted their emotionally or geographically distant care practices. When analyzing Case 3 and Case 4, this "disruption" was reinterpreted as a nuance of a broader category, *diffusing care involvement*, which was disruptive in some cases but, in other cases, promoted care collaboration between family members. Subsequent team analysis between all co-authors critiqued the first author's initial cross-case themes. Subsequently, themes were analytically delineated into *processes* and *driving forces* of collaborative appropriation. Defining key processes were considered central to describing collaborative appropriation, where "processes" were considered to be "unfolding temporal sequences … with clear beginnings and endings and benchmarks in between … and lead to change" [12]. Further analysis and case checking delineated the factors that were found to facilitate (e.g., cooperative care relationships, accessible technological support) or impede (e.g., distant or combative care relationships, limited technological acumen

or experience) appropriation. These factors were further refined into four "driving forces," and their relationships to each process were then scrutinized with data checking and, once again, refined in team analysis. This cross-case analysis generated the model that is described in Section 5.

4 CASE DESCRIPTIONS—INFORMANTS, CARE PRACTICES, AND APPROPRIATION EXPERIENCES

Toward our first study aim, for each case, we describe all informants, their care practices, and their ICT appropriation experiences during the study period. We also describe the first author's specific involvement and role within each case, which yielded different insights between cases.

4.1 Case 1: Pete, Rebecca, Alison, and Amelia

4.1.1 Informants. Pete (person with dementia, 79 years old) is Jewish-American who immigrated to Canada after marrying his second wife, Linda. Pete has an easy-going disposition and enjoys socializing, making jokes, and keeping conversations light-hearted. Since retiring from careers in research and entertainment, he has enjoyed keeping busy with traveling and joining writing groups. He was diagnosed with mild cognitive impairment (MCI) 3 to 4 years ago by a geriatrician and completed a 6-week, hospital-based patient education program on MCI. Since then, he has continued to participate in a community-based MCI support group, and a social group, which led to his recruitment into the NO program. At the beginning of the study, Pete reported that his doctor had diagnosed him with MCI and expected it would progress to Alzheimer's disease. Pete, however, was not convinced of this initial diagnosis, which he believed was based on "a terrible test." Pete reported that, the following year, his doctor had "apologized" and told Pete that his condition did not appear to be progressing to Alzheimer's disease. Six months later in the study, Pete updated Amy that his diagnosis was a topic of "controversy" between him and his doctor. Following this, with Pete's process consent (and encouragement) to openly discuss any details of his case with his daughter (Rebecca, below), Amy was told by Rebecca that Pete's most recent diagnosis was "moving on toward dementia."

Pete and Linda live in a downtown apartment building. Pete felt that Linda had become very "overprotective" since his diagnosis, and their relationship is now more "separate" than before; he attends his activities alone, and they often travel separately. Pete maintains close relationships with his son (John) and daughter (Rebecca, below) from his first marriage, who both live in the USA. Pete chats with each on the phone at least once a week to catch up and "make plans," and they each visit him a few times a year. Pete enjoys bringing them along to his community activities when they are in town. Since his recent hospitalization (during the study period), Pete has noticed that John and Rebecca call and visit him more. When Linda is away, she tries to arrange one of them to come and stay with Pete, or at least phone him every day to check in with him.

Rebecca (Pete's daughter, 52 years old) lives in the USA with her husband and two stepsons and is an elementary school teacher. She and Pete have always had a very close and open relationship. She has always been supportive of his interests and activities and has been especially committed to helping him stay active (e.g., through his NO program participation) and in good spirits, given his recent health issues.

Alison (Pete's initial volunteer, 20 years old) is an East Asian-Canadian university student who had been volunteering at the NO for 1 month. Before the study, she had visited Pete once at the NO and three times at his apartment. One month after the study started, however, Alison unexpectedly discontinued her volunteer role at the NO.

Amelia (Pete's current volunteer, 32 years old) is an Irish emigrant and elementary school teacher. She started volunteering with Pete 2 months after Alison discontinued. She met with Pete weekly, initially at his apartment but, more recently, at a nearby café (Pete's preference). Over the 2 months,

their meetings had grown more social in nature with less time spent on technology training. Recently, Amelia noticed some memory decline in Pete (e.g., taking the wrong bus to their meeting) and became concerned after he shared that he had been hospitalized. Having cared for a family member with dementia herself, Amelia proactively offered to the Coordinator to meet Pete more often or to discuss with Rebecca how Amelia could better support him locally.

Researcher's role. Over five in-person encounters and multiple phone calls, Amy developed friendly rapport with Pete. Amy communicated with Pete initially by email and home phone, and later intermittently on his new iPhone (i.e., phone calls, text messages) in order to arrange their meetings.

4.1.2 Existing ICT Arrangements. Pete's ICT use markedly changed over the study period. Initially, Pete was highly independent in his ICT use. He primarily used his home telephone and desktop computer for daily emailing, including photo-sharing, and occasional web browsing and Skype with John and Rebecca. He was enthusiastic about learning the CP system when presented the opportunity through the NO. He had always enjoyed new technological gadgets and was excited at the prospect of learning how to use modern-day technology. In addition, Pete felt valued when the NO had invited him to pilot the CP system, as well as sit on the NO program advisory board. He interpreted his role as a "volunteer" who was expected to provide feedback on the CP system.

4.1.3 CP System Appropriation: Nonadoption due to Working ICT Arrangements and Negative Meanings. In anticipation of getting started with the CP system and his first volunteer (Alison), Pete shared his enthusiasm with Rebecca. When he had received it, Rebecca and Pete sat together a few times to explore the CP system during her visits, and she sent him a few photos and videos. Alison and Pete, on one occasion, also tried to video-call Rebecca in the USA with no luck getting the audio to work. Rebecca reported that, despite Pete's initial enthusiasm, they both struggled to "find a purpose for [the CP system]"; Pete was proficient using his desktop PC for daily emails, including photo-sharing. He occasionally used Skype for video-calling with Rebecca, but he was mostly satisfied with their frequent telephone calls. Pete did, however, find the CP system's medication reminders useful (albeit "insistent") after Alison programmed them for him. He also ideated a creative use for the Events feature, and asked Alison to program a daily morning reminder to shut off his bed heater—a safety concern expressed by Linda. This morning chime soon became their "alarm clock." Despite this successful use case, however, Pete mostly resented not having direct control over specifying and modifying the CP system's functions, requiring everything to be managed by a "caregiver" (in this case, Rebecca or Alison) made Pete feel "like a second-class citizen." He thought it was impractical to burden others to make changes when he was used to managing his own schedule and routines, albeit imperfectly (e.g., occasionally missed medications, appointment mix-ups). His disappointment was reinforced when Alison discontinued volunteering and Pete lacked the control to deactivate the morning "alarm clock" during the darker winter months. He resorted to unplugging and hiding the CP system away to avoid its disruptions. Ultimately, Pete concluded that the CP system would be useful for people who are "further along" (i.e., in their cognitive decline) and more dependent on other people for daily help.

4.1.4 iPhone Appropriation: Supported Adoption, Intermittent Learning, and Divergent Meanings. Throughout his experience with the CP system, Pete reported that his son (John) had urged him to consider the iPhone instead. Both John and Rebecca thought that Pete would enjoy learning to use its social features and being able to keep in touch while he was out and about. Pete grew more excited about the iPhone after a few outings with John to the Apple Store during his visits to Canada. After Pete's decision to discontinue using the CP system, John purchased Pete an iPhone

and Rebecca agreed to pay the monthly subscription. Initially, Rebecca reported that they all enjoyed trying out FaceTime (video-calling). Rebecca, however, soon realized that the iPhone may be too complicated for Pete to learn, given no previous cell phone experience and no one local to help him practice with it daily. She also noticed that Pete's abilities were declining, and everyday tasks were taking him longer. She had tried crafting her own iPhone "flashcards" with step-by-step instructions (e.g., *How to take a photo using your iPhone*) but noticed no progress by Pete. Amelia did occasionally offer to help Pete with his iPhone during their meetings (e.g., set up daily alarms for his medications), but she was not an iPhone user herself, and Pete preferred to spend their meetings chatting. Altogether, Pete's iPhone learning was slow and piecemeal. Unlocking his phone was observed to be slow and laborious (e.g., difficulty keeping track of which digit he had just entered), but he insisted on a six-digit passcode for his own security against Rebecca's and John's advice. Pete had also not saved many numbers in his contact list, which led him to sometimes confuse with whom he was communicating. Text message responses to Amelia and Amy were delayed by days (if sent at all), and he missed multiple voice calls. Rebecca had the impression that Pete rarely used his iPhone. More than the subscription costs, she was concerned that Pete's slow learning was discouraging and adding to his anxiety about cognitive decline. She agreed that John had the best of intentions with the iPhone purchase, but she lacked confidence that Pete would be able to master it. In contrast, Pete had quite a positive attitude toward his iPhone. He admitted that he was slow to learn but repeated with pride that his kids had bought it for him, and he was appreciative and happy to let them "pull him into the 21st century."

4.1.5   TeamViewer Appropriation: Crafting a New, Mutually Meaningful Care Practice. Toward the end of the study, Rebecca shared her recent concerns about Pete's waning email use, despite previously being a daily practice that he valued. She had proactively logged into his email account, which immediately confirmed that he was extremely behind on reading and responding to even important messages from family members and his valued writing group. Seeing this "quantified" to Rebecca that Pete's cognitive abilities had indeed declined, which mobilized her to "take charge more." She started a new daily practice of logging into his email and deleting some emails, hoping to make it more manageable for Pete to catch up. She reported that Pete had no problems with Rebecca accessing his account, but was concerned about burdening her with this task, plus losing control over which messages were deleted. This led to a daily practice of reviewing his inbox while they were on the phone. This was initially time-consuming, where Rebecca first had to talk Pete through the login process and then verbally describe what she was doing as she navigated through his email interface. This shared practice, however, improved markedly when Rebecca's cousin recommended TeamViewer, a screen-sharing application that allowed Rebecca to remote-control into Pete's computer. Using TeamViewer while on the telephone, Pete and Rebecca could review his inbox together, Pete could instruct Rebecca as to which messages to delete, and Pete could see how Rebecca was doing it. To Rebecca's delight, Pete eventually learned how to do this independently with minimal remote-access and prompting by Rebecca. Despite the time and effort involved, Rebecca was "happy to do it"; she felt good about supporting Pete and she knew how much he appreciated her efforts and valued being able to manage his email again.

4.2   Case 2: Daniel and Alison

Daniel (person with dementia, 77 years old), Caucasian, is a former bus driver and former volunteer at his late mother's (with Alzheimer's disease) care facility while taking care of her. He moved to the city from a small town 10 years ago to live with his only son, daughter-in-law, and granddaughter. He lives in their basement suite with his own kitchen, bathroom, and single bedroom, which he also uses as his living area and office. Daniel appears to be in good physical shape and

is warm and soft-spoken. From his recollection, he was diagnosed with Alzheimer's disease about 4 years ago and struggles to place words and keep up during social conversations.

Daniel is highly independent in his day-to-day life and activities, and he reported that he did not know "anybody who might be interested or available" to participate with him in the study. He describes his relationships with his family members upstairs as distant and tense. He reports that they travel often and perceives them to be too "busy, busy, busy" for quality conversations. Admitting that he mostly "tries to stay out of the way," he primarily communicates with them about his household tasks (e.g., feeding the dog, garden) and when he housesits during their travels. He describes experiencing intermittent moments of "blank space" and confusion, during which he prefers not to interact with anyone. He feels that this withdrawal and his dementia are misunderstood by his family (e.g., perceived as rudeness), and he wishes for a separate entrance to his suite. In later interviews, Daniel shared that his son had suggested that Daniel may need to find an alternative living arrangement, but Daniel was unsure if and when that would happen; serious family conversations are few and far between. Daniel's strained family relationships motivated him to "branch out" socially, especially now that he no longer drives and visiting old friends is infrequent. The year before the study, he happened to drop in to the NO one day and got a "good feeling." He gradually started attending the NO's meal events and senior's programs, and also likes to "hang around" in case someone can help him with his iPhone or tablet.

Alison (Daniels' first volunteer, described in Case 1) is the same volunteer as described in Case 1. She met Daniel once at the NO and during one home visit with Amy, before she discontinued her volunteer role at the NO.

Researcher's role. Amy (first author) met Daniel on six occasions during recruitment and data collection—once in his home and five times at the NO. After the first home visit, he requested to meet at the NO due to his tense family environment. Playing a concurrent role as an NO volunteer, Amy fielded a few of Daniel's iPhone questions. After confiding in her about his family situation, she conveyed Daniel's housing concerns to the Coordinator and provided him information for support at the province's Alzheimer's Society.

4.2.1 Existing ICT Arrangements. Daniel owns two tablet computers (Galaxy and iPad), an iPhone, and several peripherals (Bluetooth keyboard, printer, router), but reports that he has been mostly unsuccessful in "getting things to work." Over time, he has accumulated these on the piece-meal advice of tech-savvy friends and store sales staff but feels that no one had the time nor an understanding of his needs to teach him how to use anything. He mostly blames "[his] mind" for not being able to learn the "language" of today's technology. Determined to "get answers" to his many technological questions from empathetic people, and to foster new social relationships, Daniel was keen to participate in the NO's pilot program by trialing the CP system. Over the course of the study, Daniel had developed new relationships with NO program staff from whom he regularly asked for support with his iPhone and tablet computer.

By the study start, Daniel had managed to master a few functions on his iPhone—his newfound "lifesaver"—by piecing together support from acquaintances at the NO, friends, and store staff. He now used it as his one trusted source for verifying the date and time. Learning how to make voice calls and text messaging also meant that he could communicate briefly and directly with his family members, which he preferred to in-person conversations that he felt to be straining within their fast-paced lifestyles. Daniel had also found tremendous meaning in mastering how to take and review photos on his iPhone; using it helped him document and recall his outings, and his photos gave him conversation topics and experiences to share with others. For example, when scrolling through photos during our home visit, we shared laughter with Daniel as he happily retold stories of his encounters with remarkable ease and detail.

4.2.2 CP System Appropriation: Nonadoption due to Complicated Technological Adaptation and Inadequate Care Partner Support. Although the Coordinator had met Daniel's daughter-in-law during her home visit, Daniel elected to participate in the NO program and study without a care partner. After two meetings between Daniel and Alison at the NO, Alison and Amy visited Daniel at home for his first training session. By then, Daniel admitted that he had entirely forgotten what the CP system was for and his role in the program. As we started reminding him of its features, he proposed that the CP system might be a good way for the NO program to "broadcast" information (e.g., calendar reminders for upcoming events) to its program participants—a use that the NO program had not intended but later considered offering. He thought this would resolve his feeling of being "disheveled in my mind" when trying to manage the program's paper brochures and remembering which program he was to attend on which date and time.

Getting started with the CP system training sessions introduced several technical problems. Initially, there were problems connecting to the home Wi-Fi network, which repeatedly sent Daniel upstairs to seek help from his daughter-in-law, whom we noted he never invited to join us. Once finally connected, Alison reintroduced Daniel to the Messaging feature. He struggled to use the touchscreen keyboard and Alison was unable to connect his Bluetooth keyboard to the CP system. We moved on to trying the Photos feature, as Daniel thought he could transfer photos from his iPhone. This led to difficulties resolving why the CP system could not receive the photos as email attachments from his iPhone. After much trial and error (e.g., emailing test photos from Alison's smartphone), we realized that Daniel's email address needed to be added to the CP system as an "authorized" Contact. Alison, who was still training on the CP system herself, had overlooked this requirement. Despite eventually resolving the issue, our protracted troubleshooting process left Daniel feeling all the more confused, excluded from the process, and discouraged about his limited technological knowledge.

After this visit and Alison's discontinuation of her volunteer role, Daniel decided that the CP system was not suitable for him. He concluded that he did not have family members who were available to help him manage his content, nor was the CP system as portable as his iPhone or tablet computer. It also seemed unsuited to his goals of typing comfortably and printing out his personal journals. He had found that typing allowed him to get his thoughts down quickly and clearly and printing out his journals might be a better way for him to communicate; not only would sharing his journals create conversation with his family members, they had also previously complimented him on his writing, which made him feel good about himself. Instead, he was determined to persist in learning to use the devices that he had already purchased. Daniel also felt it was not enough for him to learn to use individual devices; he felt he also needed to learn more broadly and cumulatively so that he can be conversant in the "language" of technology that everyone else seems to speak.

4.2.3 iPhone Voice Recorder Appropriation: Leveraging Acquired Knowhow and Available Support to Create Meaningful Self-Management Practices. At the end of a later interview, when Amy had stopped her audio recorder, Daniel expressed an interest in having an audio recorder. Spontaneously, Amy pointed out that Daniel had a native voice recording application on his iPhone and he excitedly asked for her instruction. Amy mapped the application to his iPhone home screen and stepped through the process of how to access the application and then start, stop, and save the audio recording. Daniel practiced the process once by himself, and Amy noted how quickly and comfortably he was able to recall and repeat her actions, navigating through each interface with comfort and ease. She juxtaposed this learning pace with his labored pace of navigating through the CP system—an entirely unfamiliar interface. At the beginning of their next interview two weeks later, Daniel showed Amy that he had started making a habit of using the voice recorder during meetings and conversations, and proudly placed his iPhone on the table to show that he had started his own audio recording.

4.3   Case 3: Edwin, Anita, and Wendy

Edwin (person with dementia, 55 years old) is a Chinese-Canadian former businessman who emigrated with his family from Hong Kong. He lives in a house with his wife (Anita) and their three kids, who all attend university locally. In 2010, Edwin was diagnosed with hydrocephalus and underwent neurosurgery, which left him with brain damage, further complicated by a diagnosis of Alzheimer's disease. Edwin, who was the family's sole income provider, stopped working in 2012 after being admitted to hospital, completing in-patient rehabilitation, and then coming home. As Edwin is susceptible to seizures, Anita provides constant supervision. Edwin attends a day centre twice weekly plus a weekly dementia social group. A personal support worker comes to the home one afternoon each week. He and Anita have grown accustomed to always being together outside these programs. Although they can no longer travel as much as they would like, they go on daily walks, run errands together, attend church, and meet friends at different restaurants.

Anita (Edwin's wife, 54 years old) is a former professional secretary from Hong Kong. She stopped working after their second child to take care of their home and kids. These days, Anita says with mixed feelings that she and Edwin spend "almost twenty-four hours" together. Practically, she manages the household and all of Edwin's care and activities, but was observed to regularly check with Edwin about his preferences before making decisions (e.g., study participation, inviting Amy into their home). Due to his risk of seizures, she avoids leaving Edwin alone for more than 15 minutes. She also worries that he will be inactive and unstimulated, which she finds dampens his mood. She therefore tries to keep him busy by suggesting simple chores for him to do (e.g., washing plates), turning on programs for entertainment (e.g., television and Internet radio), and arranging social outings with their friends. She helps Edwin develop and maintain relationships with his family members, friends, and new acquaintances. Lately, Anita feels overwhelmed and wishes her kids would help her more, but she finds them preoccupied with their studies and social lives. She is thankful for Edwin's personal support worker, with whom they both developed good relationships over the previous 3 years. Their case manager suggested that Anita consider placing Edwin at a respite center when she wants a break (e.g., travel with her friends), but Anita does not want to hurt Edwin's feelings; he will feel confused and abandoned without her, and she would feel terribly guilty.

Wendy (Edwin's volunteer, Case 4 family care partner) met Edwin and Anita at a social club for persons with dementia and referred them to participate in the NO program, for which Wendy became their volunteer supporting their CP system training. After two sessions, however, Wendy experienced health problems and stopped volunteering. Anita was reluctant to onboard a new volunteer, concerned how well Edwin would get along with someone entirely unfamiliar. They have discussed Wendy resuming her support when she is back to health.

Researcher's role. After meeting twice during recruitment and developing trust and rapport, Edwin and Anita invited Amy (first author) to volunteer with them in their home. Amy spent two visits providing technical support to Anita on the CP system, which led to configuring and troubleshooting it together with several of their existing mobile devices.

4.3.1   Existing ICT Arrangements. Managing ICTs is integral to how Anita supports Edwin daily; it mediates his enjoyment of constant stimulation with her priority of promoting his mental and physical activity while she manages their household, family, and care routines. As all of their ICTs (i.e., laptop, smartphone, smart TV) are too complicated for Edwin to use independently, Anita must find content that he would enjoy, turn on the device(s), and set up the content to play. Anita also facilitates Edwin's social communication. He has the same smartphone as Anita but relies on her to use it. They mostly use WhatsApp (text messaging application) to keep in touch with Edwin's mother and sister in Hong Kong, as well as participate in a group chat with

their Hong Kong friends. Anita needs to alert Edwin to new messages and open them for him to read. She admits that neither she nor Edwin has a strong technological acumen so, for more complicated setup and configuration tasks (e.g., creating new accounts, passwords, settings), she either asks their kids for help or they hire technicians. With Wendy's recommendation and initial training support, Anita was interested to participate in learning the CP system. As the television and computer had become "too complicated" for Edwin to use independently, Anita hoped that the CP system could provide Edwin with ongoing stimulation and entertainment that tended to lift his mood and "arouse his spirit." After discussing with Edwin, they agreed to participate in the NO program to see if the CP system could benefit them. Anita, however, did not expect her and Edwin to benefit from using it as much as Wendy and Patrick, who lived separately.

4.3.2   CP System Appropriation: Selective and Unanticipated Feature Use, Complicated Technical Configuration, and Purposing Different Devices for Different Needs. Initially, Edwin and Anita received two training sessions with Wendy on the CP system. Subsequently, Anita received additional training and troubleshooting from Amy. For Edwin and Anita, appropriating the CP system came with successes, challenges, and unanticipated uses. Initially, Edwin had difficulty remembering what the device was for but grew fond of it over the study period, especially as Anita grew proficient in adding content to it. By the end of the study, Edwin had started using it regularly to browse through family photos and videos, which made him "feel loved" and as if he had his own "personal computer." The reminder features, however, were less amenable to Edwin, despite Anita's efforts. For example, Anita had hoped Edwin could learn to respond to Event reminders that she programmed. Through trial and error, she learned to create successive reminders leading up to an event (e.g., leaving home for appointment), as Edwin would quickly forget with a single reminder. Edwin, however, admitted that he preferred to "have conversations" rather than responding to a chime. As such, in persisting in her verbal prompts, she unexpectedly discovered the CP system's Medication reminder valuable to her: the chime alerted her to remind him of his medications, which she would occasionally forget to do on a busy day. Appropriating the Messaging feature also came with a positive albeit unexpected outcome. Initially, Anita felt they would not use this feature because she and Edwin lived together. However, as Edwin started to use the CP system more frequently, Anita tried sending him messages when she was out of the house (e.g., notifying him she was delayed in coming home, suggesting some light chores or activities to keep him busy). She was pleasantly surprised that, after she had shown him the text messaging feature a few times, he had learned to send back simple replies (e.g., "OK"). These replies gave Anita peace of mind to know that he was safe and comfortable on his own, and having this connection to Edwin gradually allowed her to feel more comfortable leaving home for *slightly* longer periods of time. The last feature that Anita and Edwin came to enjoy was the Exercise video (i.e., the NO program loaded by the NO onto the CP system), which they would often do together. Hoping to add more exercise videos, Anita requested Amy's help to find and add new video content to their CP system.

In response, Amy attempted to add to their CP system's Web Links list (1) their preferred Chinese Internet radio website, and (2) additional exercise videos from YouTube. These goals led Amy and Anita to extensive technical configuration and troubleshooting over two visits (in total around 3 hours), in addition to multiple email exchanges between Amy and the CP system's technical support personnel. The problems that were encountered included the following.

- Media player incompatibility between those supported by the CP system and the one used by the Chinese Internet radio website.
- Apple ID requirements, where Anita needed to reset her Apple ID in order to download the web console iPad application, but did not know what password her daughter had specified

for her account. The password retrieval emails turned out to be sent to Edwin's email address, not to Anita's. Additionally, Anita needed to enter valid credit card information even to download a free iPad app.

- Hidden URLs to the desired YouTube videos when using the YouTube iPad app, which was incompatible with the CP system, which required the URL to save a specific website.
- Multiple steps (i.e., four clicks) to view YouTube videos in full-screen mode on the CP system.
- Losing sound on the CP system due to the device battery level dropping below a specific threshold, without a notification indicating that it must be placed back on its charging base for sound to resume.

Ultimately, the goals of accessing the Chinese Internet Radio website and adding exercise videos from YouTube were both partially achieved. Amy and Anita were unable to add the Chinese Internet Radio website to the CP system, but instead saved it as a bookmark on Anita's iPad Mini, which meant that Edwin would still need Anita's help to access it. Fortunately, however, Anita and Edwin realized that accessing this content on her iPad Mini would allow Edwin to enjoy this content on a more portable device, which meant that he could stay entertained when they were away from home (e.g., while traveling). Secondly, a YouTube playlist of tai chi videos was added on the CP system, but, again, Anita would need to help Edwin click through to play the videos in full-screen. Nevertheless, both Anita and Edwin were pleased with the outcomes, which were beyond their initial expectations of the CP system. Anita, in particular, however, recognized the time, knowledge, and efforts, in collaboration with a third-party, which were needed to configure her devices and applications. While she felt that her kids would not have persisted through the troubleshooting process, she still felt apprehensive about onboarding a new NO volunteer, in case Edwin did not feel comfortable.

4.4 Case 4: Patrick, Wendy, and Max

Patrick (person with dementia, 71 years old) is a German-Canadian former web press editor and former mariner. Four months prior (during study recruitment), he moved from living independently to an assisted living residence in a one-bedroom apartment. He was diagnosed with Alzheimer's disease 4 years ago. He is divorced but remains close and primarily supported by his former wife, Wendy. The two had committed to supporting each other to "age gracefully," which Patrick does by "keep[ing] an eye on" Wendy and cooperating with her to ease her care workload. He has become more cognizant of this since Wendy experienced a "burnout period" and was hospitalized. Patrick and Wendy have two adult children (Max in a smaller city in the same province and Melissa in the USA) and five grandchildren. Patrick and Wendy used to travel together to visit their children and grandchildren, but now their family members come to visit them. Patrick has a gentle demeanor with a quiet sense of humor and speaks softly and slowly, pausing frequently to find the right words. During group conversations, Wendy was observed to frequently provide him cues and clarifications, for which he seemed comfortable and appreciative.

Wendy (Patrick's former wife, 64 years old), also German-Canadian, is a retired nurse and now Patrick's primary "care partner" (her preferred term). She is highly organized, resourceful, and technologically competent. Admitting that she sometimes finds herself overcommitted, she keeps busy with her involvement in various Alzheimer's and community organizations. Just before Patrick moved to his assisted living residence, "running two households" led to her being hospitalized. Thanks to the care services (e.g., medications, meals, bathing) at his new residence, she has been better able to manage and is now extremely mindful about prioritizing her own health. Over the past year, she has become more communicative with Max and Melissa in requesting their

help, and stresses that the CP system has been integral to facilitating their care involvement (e.g., event management, photos and videos for social connectedness).

Max (Patrick's son, 37 years old), Patrick's son, lives in a smaller city within the same province, with his wife and three children. He is a camp director and working on his Master's degree. Over the past year, in support of Patrick and Wendy, he has started using the CP system to communicate more frequently with Patrick and relieve Wendy of managing Patrick's schedule when she is out of town. Max is particularly attuned to—even admittedly protective of—Patrick's feelings of anxiety and vulnerability, which he believes are, in part, due to Patrick's constant concern for Wendy's wellbeing. He strives to be a source of positive support for Patrick and assuages his anxieties about his cognitive decline.

Researcher's role. Amy (first author*)* maintained a researcher-only role and did not perform any NO volunteer duties for Case 4.

4.4.1 Existing ICT Arrangements.
Due to his cognitive problems, Patrick can no longer independently use his computer, which he previously enjoyed for Internet browsing. He also previously used his cell phone frequently, but now has trouble remembering he has it, what it is used for, and differentiating it from his cordless landline telephone. Patrick does, however, try to remember to take his cell phone when going on outings alone (e.g., taking transit to his social club), which he and Wendy agree is important.

4.4.2 CP System Appropriation: Negotiating and Cooperating through New Practices, Improving Family Communication, and Restoring the Social Nature of Care Relationships.
Before using the CP system, Wendy had been actively looking around for a "solution" to her overwhelming care workload; she previously considered herself Patrick's "information highway," receiving sometimes 10 telephone calls a day when he became disoriented or unsure of upcoming events. From Patrick's perspective, learning the CP system was his way of supporting Wendy by helping to reduce her workload. For both Patrick and Wendy, participating in the NO program and this study was also a way to fulfill their shared commitment to supporting Alzheimer's disease research. Due to their positive experience with and advocacy of the CP system, they have established direct relationship with the CP's founder, who provides them ongoing technical support as needed.

Particularly while adjusting to his day-to-day life at his new residence, Patrick feels anxious when he is disoriented to the day, time, and scheduled events. Although Wendy and Max regularly remind Patrick that he can "trust" the information provided by the CP system, Patrick admitted that he would not always "obey"; rather, he preferred to triangulate based on multiple "clues"— his wall clock, wall calendar, care routine cues (e.g., arrival of "pill lady," shower time), as well as information and alerts from his CP system. To Patrick, being able to make sense of information from multiple sources and successfully orientate himself meant that he could still trust his mind. Appropriating the CP system together helped Wendy and Max empathize with Patrick's anxiety about his memory difficulties. With patient and persistent use, cooperation between Patrick and Wendy, and increasingly more involvement from Max and Melissa, the CP system has become a regular tool through which Patrick's family supports him in day-to-day life.

Wendy regularly uses the Events feature to add upcoming outings (e.g., appointments) and events, and has established different communication practices with Patrick for different event types. She has learned to add multiple, successive reminders for when Patrick needs to get ready and then leave on time. For these, she will usually phone Patrick to discuss the event first and confirm that he would like to go. To ease Patrick's anxiety about forgetting the future event, Wendy will remind him that she will add the discussed event to his Events calendar in the CP system, which will trigger timely reminders. In contrast, for daily scheduled events (e.g., meals, optional leisure activities, scheduled TV programs), she will input them into his CP system without a prior
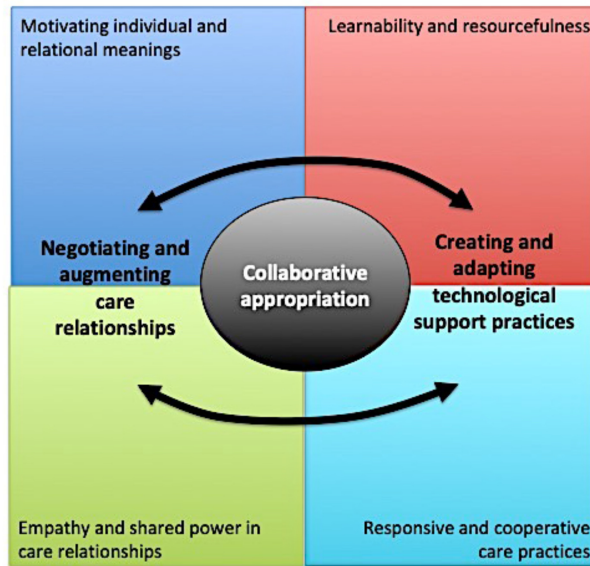
Fig. 1. Model of collaborative appropriation of ICTs by persons with dementia and nominated care partners.

conversation with Patrick. On a regular basis, Wendy is the "boss" and first to respond to any CP system alerts (e.g., missed medications), but Max and Melissa have also learned how to help with managing Patrick's scheduled activities this way when Wendy is out of town. The family also uses the Messaging and Photo features fairly regularly, which have allowed Patrick to be more "tied in" with his family (and a few of his friends) despite the distance between them. Max and Wendy have also been encouraging Patrick to use the Call Request feature, which he initially interpreted as a call button in case of emergencies.

Each family member has come to feel "grateful" for the CP system for different reasons. For Patrick, when he forgets how many grandchildren he has or how old they are, he can go into his Photos to "get the answers." Adding Google to Patrick's Web Links list has also restored his ability to surf the Internet—an activity he could no longer manage after using the computer became too complicated for him. Today, Patrick is proud to be able to do this on his own, and his family members are happy that he can resume some entertainment independently. For Max, he can involve Patrick in his young family's life more frequently and draw on this content to have enjoyable conversations with Patrick. He also likes that Patrick can initiate a chat (i.e., via Call Request) and avoid the complexity (i.e., remembering or retrieving Max's telephone number, dialing, etc.) of using the telephone to call him. For Wendy, she no longer needs to be the "go-between" between Patrick and their children and solely responsible for maintaining his social relationships. She is, however, able to manage the people who communicate with Patrick through the CP system, which she does in order to prevent Patrick from feeling confused or overwhelmed if contacted by someone he does not remember, or someone who may not understand his cognitive limitations. Moreover, with Patrick more independent in his day-to-day life, both Patrick and Wendy agree that the CP system has alleviated the "business" and tensions of day-to-day care and restored more quality time and conversations together.

5 COLLABORATIVE APPROPRIATION: PROCESSES AND DRIVING FORCES

Our cross-case analysis generated a model of collaborative appropriation shown in Figure 1. We interpreted collaborative appropriation as consisting of two related processes: *creating and*

Table 3. Processes and Subprocesses of Collaborative Appropriation

Main process	Subprocesses
Creating and adapting technological practices	"Back-end" support: independent learning, configuring, and troubleshooting ICTs for use
	"Front-end" support: teaching ICT use and negotiating support
Negotiating and augmenting care relationships	Diffusing and nominating care involvement
	Reconfiguring and developing care relationships

adapting technological practices and *negotiating and augmenting care relationships*. We delineated four driving forces that facilitate these two main processes: *motivating individual and relational meanings* that actors ascribe to the ICTs themselves or the appropriation process; the *learnability* of the ICT and related *resourcefulness* of the actors appropriating it; *responsive and cooperative care practices* that are adaptations of existing practices or newly developed through appropriation; and *empathy and shared power* in the care relationships between the actors involved in appropriation. Diagrammatically, adjacent driving forces relate to one another, and diagonally placed driving forces relate to one another through the mutually adjacent force. For example, "motivating individual and relational meanings" relate to "responsive and cooperative care practices" by influencing '"learnability and resourcefulness," and by influencing the "empathy and shared power in care relationships." Each process is situated atop the two driving forces that most influence that process. In this section, we describe each process (and subprocess) and driving forces, and how they are related to one another.

5.1   Processes of Collaborative Appropriation

Our cross-case analysis generated two main processes and four subprocesses of collaborative appropriation, which are summarized in Table 3. *Creating and adapting technological practices* involves two subprocesses: "back-end" support involves care partners (or other nominated actors, e.g., volunteers) independently learning, configuring, and troubleshooting ICTs, while "front-end" support involves care partners teaching and supporting persons with dementia in their learning and negotiating new or adapted technological support practices. *Negotiating and augmenting care relationships* involves diffusing and nominating care involvement from persons with dementia to care partners and other actors (e.g., service providers), and reconfiguring and developing care relationships. As depicted in our model (Figure 1), the two main processes inform, produce, and reproduce one another; that is, adapting technological practices leads actors to negotiate their care relationships, and, in turn, their relationship changes influence the development of their technological practices.

5.1.1   Creating and Adapting Technological Practices.

5.1.1.1   "Back-End Support": Independent Learning, Configuring, and Troubleshooting ICTs for Use. Supporting ICT appropriation required dedicated time and persistent efforts by those care partners and/or volunteers who were supporting persons with dementia in appropriation. One part of these efforts included care partners or volunteers to, first, independently learn the unfamiliar ICTs and then configure them for meaningful use by persons with dementia. Most descriptively illustrated in Daniel's and Edwin's CP system appropriation, back-end support entailed a host of technical tasks and challenges, including managing Internet connectivity; managing multiple devices and different user accounts and applications for each; adding and finding Internet content;

troubleshooting and obtaining third-party technical support; and configuring ICT features that they believed persons with dementia would be motivated and able to learn. These complex efforts involved care partners and/or volunteers exploring, practicing, and learning how to configure different features, and "programming" the specific functions (e.g., event reminder) that they would subsequently trial with the persons with dementia. Substantial time and efforts were involved in troubleshooting unexpected problems with setup and configuration, which care partners and/or volunteers attempted to resolve independently or with external support from peripheral care network members (e.g., other family members) or service providers. Through their back-end support, care partners and volunteers developed knowledge and know-how about the ICT, which guided subsequent front-end support efforts with persons with dementia.

5.1.1.2 "Front-End Support": Teaching ICT Use and Negotiating Support. Care partners and volunteers alternated between providing "back-end" and "front-end" support to persons with dementia through teaching, configuring, and adapting ICTs. Front-end support was an iterative and negotiated process whereby specific functions were trialed, teaching strategies were devised (e.g., verbal instructions, instructional "flashcards"), and meanings were ascribed to ICT appropriation by each involved actor. Front-end support tended to make visible the motivations, preferences, abilities, and vulnerabilities (cognitive and emotional) of persons with dementia, both to themselves and their care partners and/or volunteers. For example, Rebecca acquired insight into Pete's weakened cognitive abilities when she observed his waning email use. In collaborating with Pete, they established his desire to maintain decision-making control over his email inbox while relearning how to manage his email independently. This led to Rebecca's back-end efforts of seeking advice from her cousin and eventually appropriating the TeamViewer application, which would facilitate their real-time virtual practice of relearning email. This exemplifies how care partners and/or volunteers continuously learned and adapted ways of providing support within their own knowledge, resources, and constraints, and how front-end and back-end efforts relate to one another.

5.1.2 Negotiating and Augmenting Care Relationships.

5.1.2.1 Diffusing and Nominating Care Involvement. Learning new technology and obtaining technological support tended to diffuse care involvement from persons with dementia (i.e., with their own self-support strategies) outward to immediate care partners. From whom to seek support, or *nominate*, was found to be selective and was influenced by the nature and quality of the care relationship. For Edwin and Patrick, obtaining technological support from Anita and Wendy, respectively, seemed to be a natural continuation of their care relationships, whose natures already involved practical, day-to-day support. For Daniel and Pete, who were more independent in their day-to-day activities, appropriation triggered a new set of needs that they had difficulty managing independently. Seeking technological support, however, was found to confront or disrupt the established nature of their care relationships. Daniel, who described his relationships with co-residing family members as tense and preferred to "stay out of [their] way," reluctantly asked for technological help from his family members and friends. Moreover, his very reason for not adopting the CP system was that he did not feel he had the support he needed from family members, for which the system was designed. This led him to pursue new relationships at the NO program and seek support with learning his existing ICTs. Pete also found that the CP system disrupted the more social and emotional nature of his relationship with Rebecca, placing an impractical burden on her for tasks that he was accustomed to managing himself (e.g., his weekly schedule). Furthermore, the technological support that the CP system demanded, especially in the initial stages of exploration and configuration, required responsive, continuous, and knowledgeable support. This

turned out to be greater than the support that an NO volunteer could provide within a weekly time commitment.

Appropriation was also found to diffuse care involvement from primary to peripheral care partners or other nominated actors, which was also selective. Care partners also sometimes "nominated" with whom and how persons with dementia kept in social contact. For this reason, Wendy and Anita found useful the CP system's feature that allowed only invited contacts to send messages to the CP system. In Patrick's case, the CP system enabled Wendy to add Max and Melissa to Patrick's contact list. Care partners were also found to nominate others to participate in care tasks or routines through technological support. Over time, Wendy delegated and distributed some of her care responsibilities to Max and Melissa, who were previously less involved in her and Patrick's care routines. Similarly, Anita's and Edwin's children were periodically involved in supporting them technologically (e.g., setting up accounts, password reminders). Although Anita desired more support, she also felt that they needed to be selective about anyone invited into their home and whether Eric would feel comfortable. Lastly, especially to support their back-end efforts, care partners may also seek help from service providers, evidenced by both Wendy and Amy, who sought technical and troubleshooting support from the CP's founder.

5.1.2.2 Reconfiguring and Developing Care Relationships. The studied cases demonstrated the different ways in which appropriation confronted care relationships, leading actors to reconfigure their existing care relationships or develop new relationships. Learning to use text messaging on his iPhone allowed Daniel to communicate more clearly and directly with his family members, and sharing his written thoughts allowed him to express himself and feel recognized by them. As the nature and quality of Daniel's existing relationships did not lend themselves to practical and technological support, he proactively sought to develop new relationships at the NO program—thus augmenting his existing support network. Learning to audio-record on his iPhone also facilitated Daniel's new relationship building by reminding him of previous conversations. Similarly, for Edwin and Anita, appropriation led to building new supportive relationships with Wendy and Amy, which fulfilled their unmet needs for technological support that their existing relationships (e.g., with children). By developing technological support practices, Pete's and Rebecca's relationship shifted toward more practical and frequent forms of support. In Patrick's family, the diffusion of care involvement led to reconfigured relationships. Max was able to develop a more direct relationship with Patrick (i.e., independent from Wendy, their previous "go-between"), and provide practical support to Wendy in her care demands. Moreover, Max positioned his relationship with Patrick as complementary to Wendy's practical support role, in that Max prioritized emotionally supporting Patrick's anxieties about Wendy's health and wellbeing.

Lastly, in different ways between our studied cases, appropriation led to restored or enhanced care relationships. For Wendy, being relieved of Patrick's repetitive phone calls, mediating his social relationships, and scaffolding all of his leisure activities (e.g., Google) allowed her to support him "from a place of love and compassion" and restore the quality time they had previously enjoyed. Patrick, in turn, became attuned to Wendy's "more considerate" demeanor and was able to simply enjoy her company without feeling like a burden. Similarly, the independence that Edwin gained from appropriating the iPad Mini and the CP system into his day-to-day routines improved his mood and reduced Anita's worries and guilt when she was occupied or away from home. To the benefit of both Edwin and Anita, having access to entertainment on a portable iPad Mini also allowed them more freedom to go on outings and family travel because Edwin could almost or mostly access his media content independently, which allowed Anita her own leisure time. Common across all cases, the sharing of photos and videos was found to enhance the social natures of the studied care relationships. Retrieving saved media created opportunities for persons with

dementia to recall and reminisce about enjoyable events, memorable moments, and relationships of significance. This was particularly valuable in the case of geographically distant relationships, where these media bridged quality time spent together during visits (e.g., Patrick being more "tied in" and socially included in Max's family life thanks to the CP system). Moreover, sharing photos and videos *during* social interactions made for enjoyable topics of conversation, which was observed to facilitate rapport building in new relationships, such as between persons with dementia and their volunteers.

In summary, creating and adapting technological practices led actors to renegotiate their care relationships. In turn, changes to their relationships sustained and produced their new or adapted technological practices.

5.2 Driving Forces of Collaborative Appropriation

We generated four driving forces that facilitated the two described processes of collaborative appropriation: (1) motivating individual and relational meanings; (2) learnability and resourcefulness; (3) responsive and cooperative care practices; and (4) empathy and shared power in care relationships. We describe how these forces drove collaborative appropriation forward and how, if lacking or absent, appropriation was impeded or thwarted.

5.2.1 Motivating Individual and Relational Meanings. All four cases demonstrated how positive meanings that actors associated with learning or using ICTs motivated and drove their appropriation. In contrast, negative meanings, or lack of meaning, impeded or thwarted appropriation. Often, actors ascribed initial meanings to the technology or its use. These meanings, however, sometimes transformed through ICT learning, appropriation, or ongoing use, and the negotiation of care relationships.

Individual meanings derived from actors' personalities (e.g., sociable); interests, preferences, or values (e.g., maintaining autonomy); or the self-image that they wished to promote (e.g., independent). Relational meanings were often layered together with individual meanings, and concerned enhancing empathy or shared power in the care relationships between actors, and supporting their desired ways of relating to one another (e.g., offering help and assistance to enact one's value of family connectedness). First, meanings may be ascribed to simply owning or possessing a certain technology. Pete, for example, found his iPhone meaningful irrespective of his learning difficulties and intermittent use; just owning an iPhone meant that he could pursue his interest in technological gadgets, attempt to "catch up with [modern society]," and symbolized his adult children's care for him. Secondly, the technology learning process itself may be meaningful. Pete, for instance, loved learning new things and, for Rebecca, teaching and supporting Pete offered a way for her to "take charge more" in supporting for him. For Daniel, the learning process afforded him opportunities to build new supportive relationships at the NO program. Thirdly, successfully learning and appropriating technology may also produce meanings that sustain actors' use. It may mean restoring independent leisure time (e.g., through website browsing, news, photos, videos) that had been lost due to cognitive barriers to accessing previous ICTs; discovering new practices that support everyday activities (e.g., Daniel's audio-recording practice) or care practices (e.g., Anita's use of medication reminders); adapting better ways of communicating and connecting with others; or restoring the social and reciprocal aspects of care relationships through alleviated care demands. Fourthly, successfully appropriating technology may confer a sense of mastery or achievement to actors, which can be affirming both individually and relationally. Lastly, the informants in our study were additionally motivated by meanings of being valued, feeling empowered, or serving an altruistic purpose through their NO program and study participation; they felt that they were contributing to dementia research and programs to support persons and families living with dementia.

Thus, the ways in which actors construct and layer different positive meanings to technology use was found to strongly shape their appropriation decisions and trajectories.

This was also the case for negative meanings or a lack of meaning that actors ascribed to learning or using technology, which discouraged or impeded appropriation. Pete resisted the CP system because he felt it labeled him dependent on others. Rebecca, despite trying to support Pete, could not find a meaningful use for the technology vis-à-vis her and Pete's established ICT practices (e.g., telephone, email). The learning process may also be hampered if it evokes a frustration, anxiety, or sense of vulnerability for the person with dementia. A person with dementia may also resist a new technology, or some of its features, that undermines his preferences or established strategies. Both Edwin and Patrick, as examples, resisted "obeying" prompts by the CP system due to preferred or established practices. Therefore, negative meanings or a lack of meaning may lead to nonadoption when actors feel immediately alienated or disempowered by a technology's design intentions; disappropriation, where actors try it but cannot establish positive meaningful practices; or selective appropriation, where actors empathetically negotiate the use of specific features vis-à-vis their personal preferences or established practices.

5.2.2 Learnability and Resourcefulness. Together, the learnability of the ICT and actors' resourcefulness were found to drive appropriation. Learnability was related to the "resources" that actors brought to the learning process—that is, their "technological literacy" and know-how: their understanding of the ICT's functions and applications, how to interact with it (e.g., buttons, icons, gestures), its different applications, if and how it could interoperate with other hardware or software, and their understanding of its technological infrastructure (e.g., Internet connectivity, software and system compatibilities, account management, hardware requirements). For persons with dementia, cognitive resources contributed to their learnability: the ability to remember the purpose of the technology, the sequence of actions needed to initiate specific functions, and how to respond to feedback from the technology. Despite cognitive challenges, however, persons with dementia all demonstrated resources of creativity in exploring, making sense of, creating meaningful uses for, and situating ICTs within their practices. This resource allowed them to explore and contribute meaningfully to the adaptation of a technology, which facilitated collaborative appropriation. Other "resources" included the *money/means* to purchase the technologies, services, or support; the *time* to invest into learning the technology, exploring potential uses for it, integrating it into existing technological arrangements and practices, and problem-solving technical issues; and the appropriate *people* to provide technological support—those with time, knowledge, know-how, and supportive teaching skills.

When learnability and resourcefulness were limited for persons with dementia, appropriation relied more on the establishment of responsive and cooperative care practices with care partners or volunteers, where available. Creativity was especially important to care partners in crafting teaching strategies, exploring purposes for the technology, and situating the technology in order to derive benefits from it vis-à-vis existing arrangements. This was aptly evident in the way Rebecca and Pete appropriated TeamViewer to facilitate Pete's relearning of email use.

Learnability and resourcefulness were also closely related to motivating meanings. First, meanings provided a reason or reinforcement for learning technology and exercising resourcefulness in finding and obtaining the needed support resources. Care partners, for example, may be more willing to be a support resource for those ICTs that promised some meaningful benefit to themselves (e.g., Wendy expected reduced care workload from the CP system). Due to limited family support to learn technology, Daniel chose to persevere with the iPhone instead of the CP system, as he had already mastered a few functions on the iPhone, and found it easier to seek help from acquaintances with a mainstream device. Anita and Edwin were motivated to persevere with the

CP system owing to Wendy's and Patrick's positive experiences, Wendy's knowledge and initial technical support, and Amy's subsequent technical support. Similarly, Wendy had established the CP's founder as a reliable support resource, which facilitated her and Patrick's learning of the CP system. Moreover, she had additional support from Max and Melissa, who committed time to learning the CP system, which carried a meaning of family cooperation for all of them.

5.2.3 Responsive and Cooperative Care Practices. Appropriation was driven by the development of responsive and cooperative care practices between actors, which were either newly established practices or adapted from existing care practices. Effective care practices mobilized *people* as a resource for learning and appropriation. *Responsive* care practices provided support that was timely (e.g., as frequent and consistent as needed) and appropriate (e.g., effective, empathetic, context-sensitive). For example, learning and problem-solving with a new ICT may require consistent teaching or timely troubleshooting. Alison's support of the CP system, for example, was not adequately responsive to support Pete's CP system appropriation, nor was Rebecca's remote support for his iPhone learning. Persons with dementia may respond to their own needs by establishing self-support practices (e.g., Daniel's audio-recording practice), or developing support practices within new relationships (e.g., Daniel bringing his technical questions to NO program staff). Alternatively, appropriation may transform existing care practices, such as Anita herself using CP system's medication reminder, or messaging Edwin to check in when she was away from home.

Appropriation was also facilitated when *cooperative* care practices were established, wherein actors mediated differences in their respective needs, goals, and constraints, and pursued their own motivating meanings. Patrick and Wendy, for example, developed cooperative care practices through the appropriation of the CP system. Doing so promoted Patrick's independence while reducing care demands on Wendy, as well as peace of mind for both actors. Moreover, cooperating to learn and appropriate the CP system enacted their mutual commitment to supporting one another to "age gracefully," and eventually Max's and Melissa's care for both parents. Care practices were cooperative to the extent that actors were willing to respond and adapt to one another's needs, and establish practices that were mutually supportive. Importantly, cooperation and responsiveness were found to rely on a certain nature and quality of the care relationship.

5.2.4 Empathy and Shared Power in Care Relationships. Care relationships that were characterized by empathy and shared decision-making power were found to facilitate collaborative appropriation. Both characteristics supported learning and appropriating technology when emotional and cognitive vulnerabilities in persons with dementia were encountered, or the dynamics of care relationships were disrupted. As their care relationships evolved and they appropriated the CP system together, Wendy and Max, for example, came to empathize with Patrick's anxieties about feeling disorientated, and understand why it was important for him to be able to continue exercising his established orientation strategies instead of solely "obey[ing]" the CP system's alerts. Reciprocally, Patrick empathized with Wendy's care demands and cooperated with in appropriating the CP system, while persevering with the social communication features as his way of keeping in touch more with Max. Anita and Edwin also demonstrated empathy and shared decision-making in their relationship, which facilitated their appropriation. Anita repeatedly considered Edwin's feelings when making care decisions and involved him in all decision-making about their participation in the NO program and study. Reciprocally, Edwin persevered in his practice with the CP system and also came to enjoy and benefit from using it. Both examples demonstrate how relational meanings may motivate or reinforce collaborative appropriation by promoting reciprocity between actors, nurturing their relationships, alleviating care tensions, or providing alternative practices that benefit the care relationship. In contrast, the care relationships that were reportedly characterized by misunderstandings (e.g., between Pete and Linda, and between Daniel and

his family members) were not selected for program participation or technological support, even when they were co-residing. Instead, persons with dementia may choose to foster new relationships (e.g., with volunteers) in which they feel understood and empowered.

To note, collaborative appropriation was best facilitated in relationships of empathy and shared power that were *also* able to establish responsive and cooperative care practices. That is, not all of the studied empathetic care relationships were selected for technological practices, due to such influencing factors as time, distance, availability, and the nature of the relationship. For example, Pete's and Amelia's relationship developed to be more social in nature. Although Edwin felt "loved" by his children, Anita reported that, due to time and other priorities, they were minimally involved in providing practical assistance to Edwin and Anita in their day-to-day care routines. In this way, the influences of care practices and care relationships on the processes of appropriation were found to be interrelated.

6 DISCUSSION

In this study, we longitudinally examined four cases of ICT appropriation by persons with dementia and their nominated care partners and/or volunteers. Using multiple-case-study methodology, we yielded rich descriptions of how these actors collaboratively appropriated new ICTs, and how care practices were transformed or created in the appropriation process. In sum, we found that collaborative appropriation encompassed two interrelated processes, which inform, produce, and reproduce one another: creating and adapting technological practices, and negotiating and augmenting care relationships. Driving these processes were motivating meanings that actors ascribed to the technology and its use, the learnability of the technology and actors' resourcefulness, the establishment of responsive and cooperative care practices, and the qualities of empathy and shared power in their care relationships. Based on these, we highlight in this section three key takeaways for future design and implementation of ICTs for persons with dementia and their care partners. First, we accentuate the often-taken-for-granted knowledge, resources, and social support needed for ICT appropriation. Secondly, we stress that collaborative appropriation entails a meaning-making process through which actors negotiate personal and relational meanings as they explore, learn, adapt, and adapt to technology use. Thirdly, we articulate the potential of collaborative appropriation—in both its processes and outcomes—to promote positive care relationships and care practices.

Our findings underscore that the knowledge, resources, and social support (i.e., emotional and practical) needed to appropriate new ICTs by, for, or with persons with dementia warrant greater consideration. While mainstream devices, such as touchscreen devices, may indeed deliver greater usability and accessibility for persons with dementia [29], we found that the learning and appropriation of ICTs may still demand a prerequisite understanding of and know-how to navigate several "layers" of technological complexity (i.e., Internet connectivity, hardware and/or interoperability, account and password management, etc.). Care partners, or other nominated actors (e.g., volunteers), when available and willing to support these layers, may find themselves straddling multiple roles, including technology purchaser, systems administrator, technical support, and teacher, which others have also highlighted [2, 58, 60].

Our findings delineate between two intertwined streams of effort that these nominated actors may undertake: "back-end" efforts demand technological literacy and know-how, resourcefulness (e.g., seeking external support), persistence, and personal motivation; and "front-end" efforts in directly supporting persons with dementia require responsiveness, cooperation, and empathy with the unique and changing needs, abilities, and challenges of the person with dementia. Importantly, we found that learning and using technology may evoke feelings of vulnerability in persons with dementia, where they may be confronted by their cognitive or learning challenges, and feel

frustrated, overwhelmed, or discouraged. In response, a care partner may face the challenge of filtering or masking technological complexities from persons with dementia, while attempting to include persons with dementia in the process of decision-making, creative adaptations, and pursuing their learning goals. This tension resonates with how Piper et al. [58] describe care partners' "conflicting goals of protecting versus empowering."

A further support complexity we found was that technological support needs may vary over the appropriation process. Our cases indicated substantial back-end support efforts by care partners or volunteers early in appropriation, when technology features were being explored, learned, and configured. This was consistent with the "take-off" run, described by [23], which marks a period of difficulty demanding substantial social and technological support that may need to be endured before the benefits of technology use can be realized. We found that the lack of appropriate and responsive support during this period may easily lead to nonadoption or disappropriation when the potential benefit of the technology is obfuscated by technical complexities beyond what a person with dementia is motivated or able to learn, or a care partner is willing or able to support.

This also raises the temporal consideration of *when* technology may be most supportively appropriated by persons with dementia and their care partners. Previous work has typically framed this question in terms of *which stage* of cognitive decline would be most useful for technology to support persons with dementia and care partners. Tensions between introducing technology too late or too early have been discussed—that is, arguing before the point that a person with dementia has lost the ability to learn new technologies [59] and giving both persons with dementia and care partners time to learn and familiarize themselves with it [20], but not so early that it forces persons with dementia to confront their deficits [20] or overcompensates for intact abilities that can continue to be exercised [59]. Piper et al. [58] highlight that care partners adapt their technological support over time to the changing cognitive, physical, and emotional states of persons with cognitive impairment. Our model adds to this support consideration by underscoring that cognitive challenges are one among several factors to consider when timing technology for use by multiple involved actors. Our findings would pose additional questions, including: what individual and relational meanings are currently motivating the person with dementia and care partner(s) (e.g., Independence? Autonomy? A better relationship?) to adopt this technology? How learnable is the technology for each involved actor given his or her respective technological literacy and know-how, the technical complexity of the technology itself, and the available learning and support resources at present? Are there existing care practices within which appropriating this technology would provide benefit to all involved actors? Does the care relationship between actors suggest that technological support will be empathetic and collaborative, and will this technology promote the development of the relationship? Considering these driving forces together, and the way in which practices influence relationships, and vice versa, may better indicate whether all involved actors are, at any given time, positioned to appropriate and mutually benefit from the technology in question.

Secondly, our study demonstrates that collaborative appropriation is indeed a meaning-making process, which involves negotiating personal and relational meanings between actors. Such meanings that actors ascribe to ICT use may substantially influence which technologies they select, if and how they adapt their practices (or not), and whether or not usage is sustained. Meaning-making has been emphasized as central to understanding the technological experiences of persons with dementia and their care partners [27, 37, 49, 54, 62, 69]. Our study illustrated how different actors initially ascribed, negotiated, and sometimes came to make new meanings related to the technology and their appropriation of it over time.

With respect to Muller et al.'s [50] concept of *semantic adaptation* (i.e., changes to actors' meanings of technology), we found this to be related to their other forms of adaptation—*behavioral* (i.e.,

usage patterns) and *technological* (i.e., technical modifications) adaptation. For example, initially ascribing a positive meaning (e.g., social inclusion) to a technology (e.g., iPhone vs. CP system) may motivate an actor to endure a steep technological learning curve and trial new usage patterns using it. However, initial positive meanings ascribed to the technology may transform into negative meanings if, through use, actors learn that the technology disrupts their existing practices, relationships, or self-images. Moreover, the complex and onerous process of technical modifications may make an actor feel vulnerable, and, in turn, discourage them from developing usage patterns. Notably, while one actor may ascribe positive meanings—such as restored independence, reassurance, competency, or social connectedness—to their use of a particular technology, another actor may ascribe the very same technology negative meanings of vulnerability, dependence, social stigma, or social exclusion.

These differences have previously been attributed to the type of technology, specifically where actors associate mainstream and aesthetically "fashionable" products with positive self-images (e.g., independence, competence), and reject "assistive" technologies that they associate with negative stereotypes (e.g., dependence) [3]. Rosenberg & Nygård [62], who investigated the lived experiences of persons with dementia who were learning technology, found that how persons with dementia position themselves in the technological landscape seemed decisive for their learning. For instance, a person with dementia who positions himself as an "updater" may ascribe learning new technology the symbolic meaning of "being like everybody else" despite being diagnosed with dementia. This also relates to Morrissey et al.'s [47] problematization of "dementia-friendly" places, activities, or technologies. Their notion of "exclusion through inclusion" explained how such labeling may paradoxically turn persons with dementia off due to a sense of being secluded or excluded. In short, persons with dementia may be inclined toward the use, learning, or even just ownership of mainstream technologies as a way of feeling socially included in modern society.

While our findings indeed recognize the importance of how a person with dementia views oneself as technology user, we also demonstrate how meanings are negotiated between actors may bear additional influence on appropriation decisions and trajectories. For instance, where some care partners may be supportive of the emotional value of a technology over its practical usefulness, others may steer persons with dementia toward "assistive" systems that seem to deliver benefits to both actors within a more manageable "take-off run" [23]. A care partner may worry that the person with dementia may feel frustrated or distressed with the complexity of a mainstream ICT, or the ICT may not be feasible or desirable for the care partner to support due lack of knowledge or know-how, time, geographical distance, and/or competing care demands. In negotiation, persons with dementia may choose to accept technologies that care partners prefer as a way of cooperating and enacting empathy for care partners' needs, assert their own technological preferences and seek alternative supports, or negotiate a compromise (e.g., Patrick selectively "obeying" the CP system, Edwin rejecting its medication alerts but accepting social functions).

The two important insights here are, first, that persons with dementia—like any other persons—may have their own ideas about using or not using certain technologies or technological functions. In different ways, the persons with mild dementia in our study shared many of the characteristics that Bell et al. [5] used to describe their studied younger persons living with dementia: "actively involved in their health decisions, reflective about their situation, fiercely independent…." As such, it should be expected that they exercise choice and control over technological decisions and usage. In response, our studied care partners were called upon to pivot their care practices and expectations of appropriation when persons with dementia exercised technological choices. In doing so, care partners may experience a tension, which Hodge et al. [24] also found, between honoring the choices of persons with dementia and "overprotecting" them (e.g., steering them away from technologies that may seem too complicated for their cognitive abilities). Hence, our

second important insight is that appropriation is negotiated between actors and may result in unexpected ways of using (or resisting to use) the designed features of a technology. Together, these insights contribute a social relational dimension that offers an alternative explanation as to why some technologies remain in a "liminal zone" [14, 22] of being unused after being purchased, or altogether "disappropriated" (i.e., abandoned or rejected based on some evaluation through use [10]). These findings suggest that appropriation engenders important meaning-making processes that steer how interdependent actors complete design in or through use [10, 50] as they adapt to technology *and each other* in the process.

Thirdly, from our view, the most promising insights from our study describe how both the process and outcomes of appropriation may promote positive care relationships and care practices. Since Kitwood's seminal work that emphasized the importance of the psychosocial contexts of persons with dementia [31], several scholars have advocated for promoting positive dementia care relations and relationships (e.g., [1]). Empirical studies have shown how technology use may support these relationships by augmenting usual care practices [36], sustaining social networks [46], or supporting enjoyable shared activities between persons with dementia and care partners [1]. Our study describes the processes and key driving forces through which these relational benefits may be realized. For a person with dementia who does not have supportive care relationships, technology learning and appropriation goals may motivate or create opportunities to seek and build new relationships through which supportive practices can be developed. When persons with dementia are supported by care partners in technology appropriation, there may be opportunities to enhance their care relationship through mutual empathy-building, learning, and cooperation. This may support care partners in sustaining their roles, as learning, skill development, and nourishing relationships may be highly meaningful and personally affirming to care partners [9, 25]. Reciprocally, persons with dementia may feel better understood and supported by care partners, and develop a greater sense of inclusion, connectedness, and belonging—the meanings that persons with dementia have been found to pursue through their activity engagement [57]. For care relationships, restoring or improving the *quality* of time spent together—aptly highlighted by [47]—may be possible when collaborative appropriation succeeds to reduce actors' worry, stress, or time-consuming care activities.

Our findings on the processes and driving forces of collaborative appropriation also relate to how persons with dementia and care partners have been found to negotiate the impact of dementia on their relationships, according to a thematic synthesis by [34]. Specifically, we have shown how the appropriation process and ongoing technology use may help actors experience more opportunities to communicate openly about the difficulties they are experiencing, develop mutual respect and appreciation for one another, negotiate new ways of managing and coping together, and discover new ways to maintain togetherness (e.g., through enjoyable shared activities through technology use or the alleviation of care demands it allows) and time apart (e.g., independent leisure for persons with dementia, respite for care partners who may maintain greater responsibilities). In sum, the process of appropriation is not only influenced by the strength of actors' care relationships [22], but may create opportunities, in turn, to transform, nurture, and enhance those care relationships.

7 STUDY LIMITATIONS AND CONSIDERATIONS

We recognize certain limitations and methodological considerations of our study, including our sample of only male persons with dementia and an opportunistic recruitment strategy from one community-based program. As shown in Table 1, the time duration, amount of data collected, and the data collection methods used were inconsistent between cases. These variations were influenced by recruitment support offered by the Coordinator, the mutual availability of the

informants and researchers, the implications of different care arrangements (e.g., the need for separate interviews between persons with dementia and family care partners), and the differing technology skill levels and training goals between informants. The "nomination" process of care partners by persons with dementia may have been influenced by power dynamics in care relationships, and produced data that was more reflective of one informant's experiences. Informants' NO program participation and the first author's dual role as researcher and program volunteer, which differed between cases, may also have influenced informants' motivations for and commitments to learning the CP system. In particular, the extensive (i.e., hands-on, persistent, in-home) technological support offered by the first author playing her volunteer role may have introduced problems, experiences, or attitudes that informants may not otherwise have encountered. On the other hand, as [18] experienced with persons with advanced dementia, by "[extending] the role of the researcher that is more akin to that of a carer," the first author not only accessed the felt experience of providing technological and social support, but also gleaned a rich understanding of the studied informants and the relational complexities that shaped their appropriation experiences. While our complementary observational and interviewing methods aimed at addressing this, we are cognizant that a person with dementia receiving technological support may respond differently to a family care partner from a volunteer, or another party with whom their relationship is new or developing. Data collection and analysis were also limited to the sensitivity and interpretations of the first author, which team data analysis attempted to mitigate.

In general, we found that using the case-study methodology—in its employment of different data-collection methods and modalities—proved useful and insightful in the studied context. Telephone interviews made it possible to gather data from nonlocal family members or from volunteers who had limited availability outside their scheduled volunteer shifts. Communicating with persons with dementia over the telephone also revealed some of specific challenges that they may encounter (e.g., slower conversation pace). Moreover, telephone interviews or in-person interviews outside their shared residence may create opportunities to collect data from individual informants (i.e., persons with dementia or family care partners) without the presence and potential influence from co-residing informants.

8 IMPLICATIONS

Our study adds empirical support to two important notions that HCI scholars in dementia care are currently advancing: technology should be viewed as part of people's lived experiences [45, 71], not simply tools that are used, and that HCI research and design for persons with dementia should aim at enriching lived experiences, not only compensating for the cognitive deficits of persons with dementia [27, 37, 38, 48, 49]. Methodologically, both imply that traditional techniques of gathering design requirements and attempting to "parachute" into the real-world "solutions" to defined problems cannot fully capture how actors (e.g., their meanings, relationships, practices) shape, and are shaped by and through their experiences with technology. Our study stresses the need to longitudinally and naturalistically study appropriation as part of the design process in order to understand the organic ways that people make meaning with and creatively adopt and adapt to technology. We argue that such inquiries involving persons with dementia and family care partners are essential and timely as more products and services are introduced in the marketplace. Adopting a "technology-in-use" perspective [21] that employs complementary methods of interviewing, observing in-context, and participating in real-time processes is strongly recommended. Here, researchers and designers may reflexively consider how they co-construct experiences, and recognize their roles as "thinking, feeling tool[s] in the design process" [49], as different insights can be gained through different methods of accessing people and experiences. We argue that this is especially important in sensitive or vulnerable contexts, such as those

of persons with dementia and care partners who may be managing the impact of dementia on their self-identities, relationships, and everyday practices. This should be balanced with a researcher view that, despite vulnerability, persons with dementia and care partners may still exercise their power and creativity through the ways that they self-initiate strategies, and ascribe positive meanings to the learning process. A promising future direction would be to examine care networks (described further by [21]) as units of analysis that should be expected to vary widely by actor composition, actors' motivations, and the nature and quality of care relationships, which tend to be undergoing change when living with dementia.

For product and service designers, we recommend greater focus on the technology learning process and facilitating persons with dementia and care partners to learn mainstream technologies. Building applications on mainstream platforms with familiar user experiences promotes not only learnability but also social inclusion for persons with dementia in the social lives of their digitally connected family members and modern society. Application design on mainstream platforms, however, should be sensitive to the "layers" of technological complexity that may hamper accessibility by the intended actors. In the case of our studied system, for example, by only simplifying the front-end tablet intended for an older adult, family care partners with limited technological knowledge, resources and problem-solving skills struggled to learn, configure, manage, and support their relatives' use of the system. This service would be improved with greater focus on training and support. For example, dedicated training services for—and that overcome geographic distance between—persons with dementia and care partners during "take-off runs" may enable more collaborative care arrangements through the use of the system. Particularly for persons with dementia, the processes of learning (or relearning) technology should be understood as both cognitively and socially complex. Socially, it cannot be assumed that persons with dementia will automatically nominate family members for technological support, or that family members are willing or able to provide it. Persons with dementia, despite their cognitive challenges, may also value and undertake learning new technology for the sense of accomplishment, social inclusion, or greater independence that it affords them. Learning, for both persons with dementia and family care partners, may also bring about opportunities for building new and meaningful relationships. Taken together, technological support services that promote learning by persons with dementia, or support care partners' efforts, may promote mutually beneficial and sustainable care arrangements further into actors' dementia care trajectories. Notably, a greater focus on training the different "user groups" was considered a key opportunity area for service improvement by our collaborating company (CP). As the prevalence of dementia will only increase with the aging population, promoting technological acumen for persons with dementia and their care partners through such service offerings may be particularly fruitful.

Centrally, we urge design researchers and designers to thoughtfully consider care relationships and relations when designing for persons with dementia and their care partners. Living with dementia cannot be fully understood through the biomedical perspective of experiencing cognitive and functional decline, and increasing care dependency. In particular, design should recognize the creative capacities and self-management strategies that persons with mild cognitive deficits (i.e., mild cognitive impairment, mild dementia) continue to exercise, as well as the social stigma they may experience in their relations with care partners, acquaintances, and broader society. In addition, the meanings and values that both persons with dementia and care partners ascribe to technology, as well as how they navigate relationship changes, should be expected to influence technology attitudes, decisions, and behaviors. Designers and service providers should anticipate such changes with time, technology use, and social negotiations, and leverage opportunities to capture this information in order to guide and tailor services that benefit both actors.

It may also be useful for designers to more precisely match their envisaged services to users and care networks of a specific composition (e.g., multiple family members involved in care practices), nature (e.g., co-located), and quality (e.g., cooperative, empathetic) of relationship. To note, our collaborating company (CP) considered these delineated characteristics useful for their future product marketing strategy. In addition, reinforcing Piper et al.'s [58] recommendation for "gradations of support," we would also recommend that user control between persons with dementia and care partners be designated flexibly, in order for actors to organically adapt practices to the ways they choose to relate to each other. Sharing the same functionality, such as through screen mirroring or remote-control access, may scaffold persons with dementia to learn or relearn functions. The ability to assign and reassign functions between a person with dementia and care partner(s) may allow functions to be scaled back if they become too complex or frustrating for the person with dementia, or beyond what a care partner can support. Functionality that promotes collaboration between actors may beget relational benefits that, in turn, sustain new technological practices. Concretely, we recommend greater design focus on creating opportunities for persons with dementia to foster new social relationships that augment their support networks; provide alternative communication methods for persons with dementia to express themselves effectively and creatively; distribute care responsibilities to multiple care partners, where willing and available; enable care partners to provide technological support to persons with dementia, both locally and remotely; alleviate care tensions through empathy-building and shared decision-making; and promote shared enjoyment and social conversations in care relationships.

9 CONCLUSIONS

In conclusion, collaborative ICT appropriation by persons with dementia and care partners encompasses the development of technological practices and reconfiguration of care relationships—two processes that inform, produce, and reproduce one another. Driving these processes are the meanings that actors ascribe to the technologies and their use, the learnability of the technologies and actors' resourcefulness, the extent to which responsive and cooperative care practices are already established or can be established between actors, and qualities of empathy and shared power between actors in their care relationships. Technological literacy and know-how on modern mainstream ICTs requires substantial consideration when designing research, products, and services for persons with dementia and care partners. The motives, meanings, and preferences of individual actors are influential to appropriation trajectories, as are the nature and quality of their care relationships and extent to which appropriation promotes actors' relational dynamics. These technological and social complexities imply that actors may adopt and adapt (to) ICTs in creative and unexpected ways. As such, we advocate that future work employ approaches that examine care relationships and networks; learn from real-world, longitudinal cases of appropriation; and co-construct enriched, synergistic technological experiences with persons with dementia and care partners. Moreover, the goals of designing "solutions" for persons with dementia and care partners may be better framed as intentions to promote positive care relationships and cooperative care practices through enriched experiences.

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