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Older Adults' Reasons for Using Technology while Aging in Place

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Key Words
Aging in place · Technology acceptance · Technology adoption · Information and communication technologies · Gerontechnology · Consumer appliances · Smart home · E-health · Qualitative research · Model

Abstract
Background: Most older adults prefer to age in place, and supporting older adults to remain in their own homes and communities is also favored by policy makers. Technology can play a role in staying independent, active and healthy. However, the use of technology varies considerably among older adults. Previous research indicates that current models of technology acceptance are missing essential predictors specific to community-dwelling older adults. Furthermore, in situ research within the specific context of aging in place is scarce, while this type of research is needed to better understand how and why community-dwelling older adults are using technology. ***Objective:*** To explore which factors influence the level of use of various types of technology by older adults who are aging in place and to describe these factors in a comprehensive model. ***Methods:*** A qualitative explorative field study was set up, involving home visits to 53 community-dwelling older adults, aged 68–95, living in the Netherlands. Purposive sampling was used to include participants with different health statuses, living arrangements, and levels of technology experience. During each home visit: (1) background information on the participants' chronic conditions, major life events, frailty, cognitive functioning, subjective health, ownership and use of technology was gathered, and (2) a semistructured interview was conducted regarding reasons for the level of use of technology. The study was designed to include various types of technology that could support activities of daily living, personal health or safety, mobility, communication, physical activity, personal development, and leisure activities. Thematic analysis was employed to analyze interview transcripts. ***Results:*** The level of technology use in the context of aging in place is influenced by six major themes: challenges in the domain of independent living; behavioral options; personal thoughts on technology use; influence of the social network; influence of organizations, and the role of the physical environment. ***Conclusion:*** Older adults' perceptions and use of technology are embedded in their personal, social, and physical context. Awareness of these psychological and contextual factors is needed in order to facilitate aging in place through the use of technology. A conceptual model covering these factors is presented.

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Introduction

Population aging is taking place in nearly all the countries of the world, including the Netherlands, in which the percentage of people aged 65 or older is expected to increase from 16% in 2012 to 26% in 2040 [1]. In light of this development, aging in place, which can be defined as 'remaining living in the community, with some level of independence, rather than in residential care' [2], is often viewed by policy makers as a way to avoid the costly option of institutional care, and as a means to cope with the expected shortage of care professionals [3, 4]. Additionally, technology is frequently postulated as a means of supporting aging in place [5, 6]. For example, in the Netherlands, technological innovations are expected to enable an increase in the number of dwellings that are suitable for older people [7].

Various types of technology are specifically designed to support aging n place, such as emergency help systems, vital signs monitoring, and fall detection systems [8]. These technologies are sometimes referred to as Smart Home technology [9]. Additionally, there is e-Health, which encompasses a broad range of technologies, including online tools to support older adults' self-management of chronic conditions [10]. These technologies, however, have not been implemented on a large scale for various reasons [7–9, 11]. One of the reasons is the ambivalent attitude of older adults towards these types of technology: on the one hand, they recognize that such technologies could support independent living of the older population, while on the other hand, they do not feel that they personally need them [8, 12]. Additionally, there are generally available consumer information and communication technologies (ICTs) that are also expected to provide benefits to older adults who would like to remain independent. Examples include the use of social network sites to support social contact and the use of the Internet to find health-related information. However, results on the readiness of older adults to adopt ICTs are mixed. In the Netherlands, 70% of the individuals aged 65–74 make use of the Internet, and of this group 33% use social network sites. At the same time, only 30% of the individuals aged 75 or older use the Internet, and of this group 18% use social network sites [13]. This phenomenon is sometimes referred to as 'the digital divide' [14].

There are, nevertheless, several 'low-tech' types of electronic technology that are being used by the majority of community-dwelling older adults on a daily basis, e.g., household appliances, landline phones, and televisions [15, 16]. These consumer appliances also play a role in staying independent, active and healthy. It could be argued that an older adult's daily life and participation in society is, to a large extent, influenced by the use of these types of technology [16, 17]. While the population continues to age, it seems paramount to gain a deep level of understanding of what facilitates or impedes the use of various types of technology that play a role in the independent living of older adults. Not only to understand what influences the acceptance of technology that is already present in the homes of older adults today, but also to indicate how to improve the acceptance of technologies that are foreseen for implementation in the homes of older adults.

Two models often employed in technology acceptance studies are the Technology Acceptance Model (TAM) [18] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [19]. Both models originally were aimed at explaining technology (non-)use by individuals in organizations. The predictor variables in the Technology Acceptance Model are perceived usefulness and perceived ease of use, while the Unified Theory of Acceptance and Use of Technology includes two additional predictors (social influence and facilitating conditions) and four moderating variables (gender, age, experience and voluntariness of use). Recently, reviews of studies involving older adults have indicated that the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology are missing essential predictors of technology use that are specific to community-dwelling older adults, including biophysical (e.g., cognitive and physical decline), psychological (e.g., desire to remain independent) and contextual factors (e.g., available resources and role of family members) [8, 12, 20]. Another point in the current literature on technology acceptance by older adults is that most studies are focused on a specific technology of interest, rather than generating findings which are generalizable across technologies [12]. Furthermore, in situ research within the specific context of aging in place is scarce, while this type of research is needed to better understand how and why community-dwelling older adults are using technology [21]. In light of the aforementioned, a qualitative field study was set up to answer the following research questions: which factors influence the level of use of various types of technology by older adults who are aging in place, and how can these factors be described in a comprehensive model? In this pursuit, the current study was designed to include various types of technology that could support activities of daily living, personal health or safety, mobility, communication, physical activity, personal development, and leisure

activities. As such, the current study covers all cells of the technology taxonomy as proposed by van Bronswijk et al. [22]. In the current study, level of use is defined as the frequency of use.

Methods

The study was designed as a qualitative explorative field study [23].

Sampling

The study was carried out in 2012. Participants were recruited in a medium-sized town in the Netherlands. Criteria for inclusion were: (1) community-dwelling (i.e., aging in place), (2) aged 70 or older, (3) born in the Netherlands, and (4) not cognitively impaired. It was decided to include individuals aged 70 or older, because older age is related to both an increased difficulty to continue to age in place [24], as well as lower usage levels of several types of technology (e.g., ICTs and mobile phones) [13, 19, 20]. Older adults who were likely to meet these criteria were approached in person, given an information letter if they expressed interest in participating, and subsequently called to schedule an appointment. In order to support the goal of creating a broad comprehensive model, purposive sampling was used to capture the views of participants with different health statuses, living arrangements, and level of technology experience. One participant was included per household. Of the 72 potential participants, 53 ultimately agreed to participate in the study (a response rate of 73%). Health issues and lack of interest were reasons for nonparticipation. Participants were recruited through home care providers (n = 18), a senior volunteer organization (n = 15), a tablet computer project (n = 13), a local shopping center (n = 5), and word of mouth contacts (n = 2). The tablet computer project was a 1-year pilot in which 22 community-dwelling older adults were given a tablet with a customized interface which provided functions aimed at supporting independent living, such as video telephony.

Data Collection

Home visits, lasting 90–150 min, were made to each participant. At the beginning of each visit, informed consent was obtained. In the first part of the home visit, information on the participant and his or her level of technology use was gathered. This was done to provide the researchers with background information relevant to the semistructured interview, which was the second part of the home visit. Gathered background information included: educational level, civil status, living arrangement, level of formal and informal care, chronic conditions, subjective health status, frailty as measured by the Tilburg Frailty Indicator (TFI) [25], and cognitive functioning as measured by the Mini-Mental State Examination (MMSE) [26]. Furthermore, participants were asked whether they had experienced life events that were meaningful to them in the last 12 months. Additionally, background information on the level of technology use of participants was gathered by asking participants to take the researchers on a tour through their homes. During this tour, the researchers, in collaboration with the participant, drew up an inventory of electronic devices in the home. Participants were asked how frequently they used these devices and what they used these devices for. Categories used to describe frequency of use were: (nearly) daily; at least once a week; at least once a month; less than once a month, and stopped using, or never used. In each visited room, participants were asked whether there would be devices hidden out of sight. Devices were included in the inventory if they (1) required electric power in order to function, (2) were intended to be used in or around the home, and (3) could support activities of daily living, personal health or safety, mobility, communication, physical activity, personal development, and leisure activities. Additionally, participants were asked if there was any technology that they were contemplating buying or using, and whether there was any technology that they had heard about but were absolutely not interested in.

In the second part of the home visit, participants were interviewed on reasons for their level of use of three technologies. Which technologies were discussed depended on preferences of the participants (who displayed strong feelings towards certain technologies) and on suggestions by the researchers (who aimed to understand the usage of multiple types of technology). In particular, the researchers aimed to include technologies that were integrated in the daily lives of participants, as well as technologies that were not, or to a lesser extent. Interviews were semistructured, and typical opening questions included: 'Can you explain to me why you are using this technology on a daily basis?'; 'Can you tell me why you stopped using this technology?', and 'Why are you contemplating buying this technology?'. Interviews were partially retrospective, seeking explanations as to why a technology came into the home originally, and whether or not expectations regarding the technology were met. Initially, a topic list based on a systematic review of factors influencing acceptance of technology designed to support aging in place was used [8]. Topics included benefits, concerns, social influence, perceived need, barriers, facilitators, stigmatization and cost. This topic list was adjusted as data collection progressed. Visits were performed by two researchers: one psychologist trained in interview techniques (S.T.M.P. or M.D.R.), and a second researcher with a background in healthcare or engineering (M.E.N., C.S.v.d.V. or J.v.H.). Both took field notes. At the end of the visit, participants were offered a magazine subscription of their choice. All interviews were audiotaped and transcribed verbatim. Member checking was performed by sending a summary of the interview to each participant. During this process, 1 participant responded that she was misinterpreted on one occasion during her interview, which was taken into account while analyzing that particular interview. The Ethics Review Board for the Tilburg School of Social and Behavioral Sciences approved the study. During the home visits, 3 participants stated that they were younger than 70 years. Because of ethical considerations, these participants were not excluded.

Analysis

Thematic analysis [27] was employed to analyze the transcripts. Using qualitative data analysis software (Atlas.ti version 6), inductive codes were attached to quotations relevant to the research question. In this process, factors described in the aforementioned systematic review [8] were used as sensitizing concepts [28]. Each transcript was coded independently by 2 researchers, who subsequently had to come to an agreement to produce a single coded version of each transcript. Coding was detailed; often multiple codes representing different factors influencing technology use

Table 1. Sample characteristics (n = 53)

Age (mean ± SD), years	78.0±6.0
Age	
65–69 years	3 (5.7)
70–74 years	11 (20.8)
75–79 years	21 (39.6)
80–84 years	11 (20.8)
85–89 years	5 (9.4)
90+ years	2 (3.8)
Gender	
Female	34 (64.2)
Male	19 (35.8)
Living arrangement	
Alone	38 (71.7)
With a partner	15 (28.3)
Receiving home care	
Yes	34 (64.2)
No	19 (35.8)
Educational attainment	
No or primary education	17 (32.1)
Junior secondary vocational education	11 (20.8)
Secondary vocational education	5 (9.4)
Secondary education	13 (24.5)
Higher education	7 (13.2)
Subjective health	
Good, very good or excellent	38 (71.7)
Fair or poor	15 (28.3)
Number of chronic conditions (mean ± SD)	3.9±2.2
Number of chronic conditions	
0	1 (1.9)
1	5 (9.3)
2	13 (24.1)
3+	35 (64.8)
MMSE score (mean ± SD)	27.8±1.7
MMSE score[a]	
24–26	11 (20.8)
27–30	42 (79.2)
TFI score (mean ± SD)	4.5±2.7
TFI score[b]	
0–4	25 (47.2)
5–15	28 (52.8)

Data represent number of subjects and percentage given in parentheses unless specified otherwise.

[a] As suggested by Kempen et al. [48], a score of 24 was used as the cutoff point for cognitive impairment.

[b] As suggested by Gobbens et al. [25], a score of 5 was used as the cutoff point for frailty.

were attached to quotations. Every week, coded transcripts were discussed within the team and then combined into one Atlas.ti file. In this way, new codes were added, overarching categories of codes were formed and refined, and a model of the findings was shaped. The entire process took 8 weeks, and in the last 2 weeks, few new codes were added, indicating that data saturation was reached. A Microsoft Access database was built, based on the input from the inventory of electronic devices, and then used to calculate the number of electronic devices owned by participants and to determine the frequency of use of these devices. These data and the data on background information of participants were entered in SPSS version 21 in order to produce descriptive statistics.

Results

Sample Descriptives

The sample consisted of 53 participants whose ages ranged from 68 to 95 (table 1). The average age was 78 ± 6.0, and 64% of the participants were female. Just over 71% of the participants lived alone, and 64% received home care. Of the participants, 32% had attained no or only primary education. Nearly 55% had attained some form of secondary education, while 13% attained higher education. The majority of the participants (71%) considered their health to be (very) good or excellent. Additionally, nearly 65% of the participants had three or more self-reported chronic conditions. Just over 52% of the participants were considered frail according to the TFI, and none of the participants were cognitively impaired, according to the MMSE.

Descriptives of Technology Ownership and Use

On average, participants owned 32.9 ± 8.0 devices. Table 2 shows that, within all types of technology, there was a considerable amount of variation with regard to the number of devices owned. The majority of the devices owned were home and personal care appliances (median = 16, range 7–32) and entertainment appliances (median = 7, range 2–17). Assistive devices and home automation devices were predominantly used on a daily basis. Additionally, around two thirds of the home and personal care appliances, ICT devices, telephones, and transportation devices were used daily or weekly. Around half of the entertainment devices and one third of the home fitness equipment were also used daily or weekly. In total, 19% of the devices were not used at all. Compared to other types of technology, entertainment devices, home fitness equipment, and transportation devices were more often not used.

Emergent Themes

It was found that the level of technology use in the context of aging in place is influenced by six major themes: challenges in the domain of independent living, behavioral options, personal thoughts on technology use, influence of the social network, influence of organizations,

Table 2. Number of devices per participant and average frequency of use in the last 2 months, by type of device (n = 53)

Type of device	Examples	Devices per participant, n		Average frequency of use in the last 2 months				
		median	range	(nearly) daily, %	at least once a week, %	at least once a month, %	less than once a month, %	stopped using, or never used, %
Assistive devices	personal alarm buttons, hearing aids, and electric lift chairs	1	0 – 8	62.9	5.6	5.6	7.9	18.0
Entertainment appliances	televisions, cameras, and CD/DVD players or recorders	7	2 – 17	41.0	10.8	6.0	14.4	27.8
Home automation	remote-controlled power sockets, intercom systems, and motorized rolling shutters	1	0 – 2	65.9	18.2	2.3	4.5	9.1
Home and personal care appliances	microwave ovens, washing machines, and electric toothbrushes	16	7– 32	35.3	27.0	11.4	11.9	14.4
Home fitness equipment	treadmills and exercise bikes	0	0 –2	10.0	20.0	10.0	30.0	30.0
ICT devices	desktops, laptops, tablet computers, and printers	2	0 – 8	44.4	23.4	4.8	8.9	18.5
Telephones	landline phones, feature phones, smartphones, and senior phones	3	1– 6	37.7	29.2	2.6	10.4	20.1
Transportation devices	cars, bicycles, and mopeds	1	0 –2	32.7	26.5	4.1	6.1	30.6
Total	–	33	17 – 55	39.5	21.7	8.1	11.7	19.0

and the role of the physical environment. These major themes and their subthemes are displayed in figure 1, and are described in the following paragraphs.

Challenges in the Domain of Independent Living

Participants frequently mentioned challenges that were related to independent living. First, participants spoke about basic needs that they wanted met, such as the need to stay independent: 'I don't want to be dependent on anyone. I like to do everything myself' (P14). They also mentioned the need to stay safe, the need for personal contact, and the need to pass the time. Second, participants spoke about activities that they wanted to perform on a regular basis, including household chores, hobbies, and voluntary work. These activities could involve the use of technological means, for example, 1 participant used the computer to do the bookkeeping for the local bridge club. The third challenge was the participants' health status and the health status of the participants' partner. Health decline was something most participants cared not to think about, but, nevertheless, was lurking in the background: 'You never know, it can hit you any time. Today you can be healthy, and tomorrow you've got it' (P15). Cognitive and physical decline could limit the use of certain types of technology (e.g., household appliances, ICT devices) and at the same time induce the use of other types of technology, for instance, the use of a personal alarm button: 'You know things will get worse, that's why I bought it' (P7).

Behavioral Options

To participants, the use of technology was only one of several behavioral options to cope with challenges in the domain of independent living. Participants frequently mentioned alternatives that competed with the use of technology. Often, participants stated that they did not have to make use of technology or any form of assistance, because they could handle things on their own: 'I handle a lot of things by myself... I am stubborn, proud, how should one call it?' (P20). The use of technology also competed with assistance from other persons, often family members. An example of this is a participant who participated in the tablet computer pilot project, which provided a grocery delivery service: 'Yes, I can order groceries, and they can deliver them to my house… I can also call my son and he will bring them…' (P8). Other participants asked family members to use a computer so that they did not have to do so themselves: 'I do not need my computer… When something is really important my daughter will use her computer' (P12). Finally, the use of one type of technology also competed with the use of other types of technology. Often, these other types of tech-

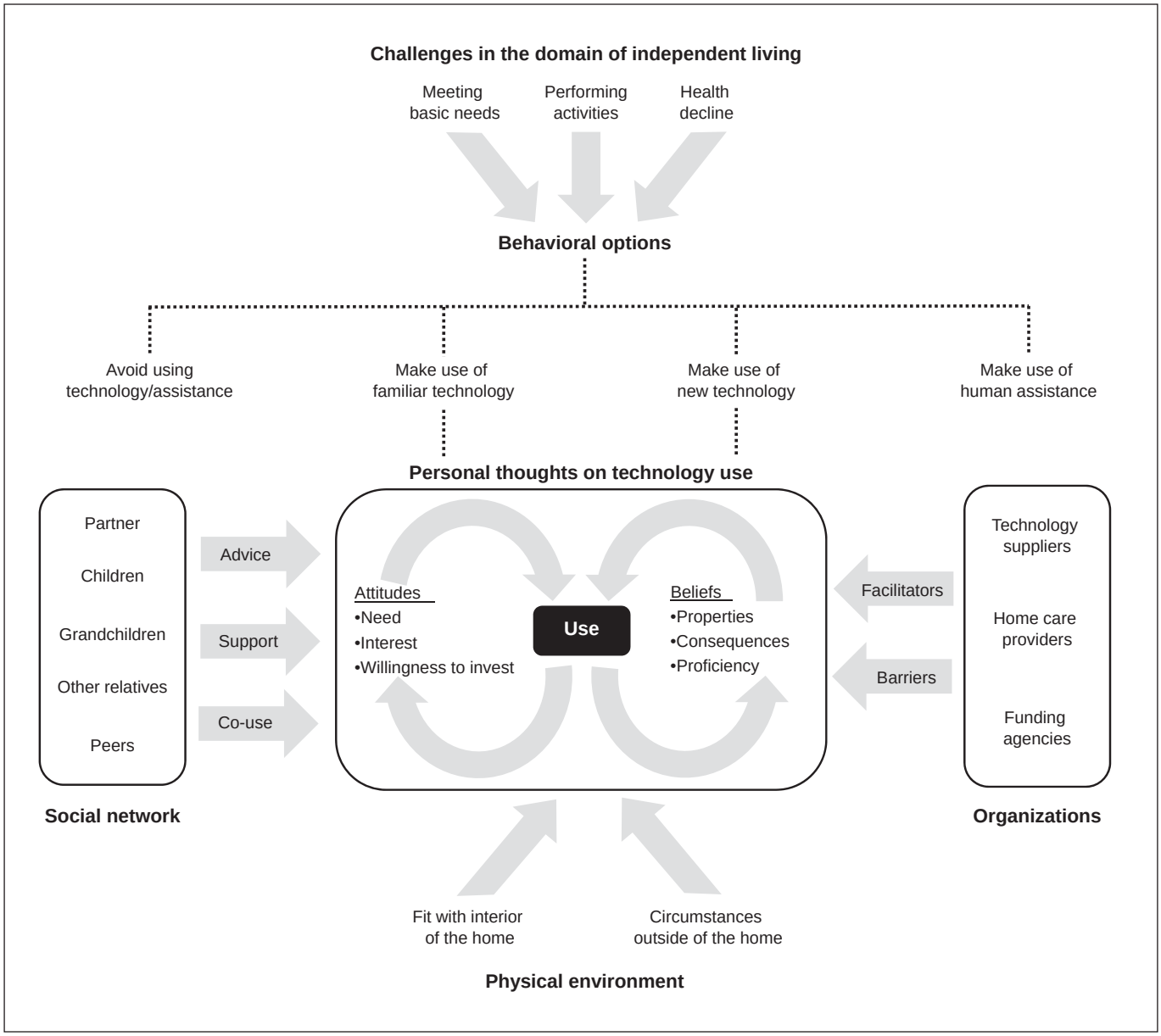

Fig. 1. Conceptual model of factors influencing the level of technology use by older adults who are aging in place. Major themes are in bold type, subthemes are in normal type.

nology were of a previous technology generation and more familiar to the participant. An example is the use of a landline phone instead of a mobile phone: 'I find my landline phone convenient… I don't want two… A mobile phone and a landline phone, that's too much for me' (P3). Choosing between these behavioral options did not seem to be a very conscious process among participants, and often the interviews were the first time they thoroughly reflected upon their reasons for using technology.

Personal Thoughts on Technology Use

Participants expressed various attitudes that were relevant in the pre-usage stage (when they had not used a technology) and in the post-usage stage (when they had used and experienced a technology). Three attitudes could be discerned: the perceived need for technology, the interest in technology, and the willingness to invest in technology. Whenever participants did not use a technology, they often stated that they did not see a need for it,

particularly when assistive technology, ICT devices, or mobile phones were discussed. When participants did use technology, their opinions on whether they needed it varied. Regarding participants' interest in technology, participants often spoke in general terms as if they were a technology-minded person: 'I've always loved everything that is technical' (P9), or a 'nontechnological' person: 'These electrical things don't interest me. Like these mobile phones, I always call them children's toys' (P26). The willingness to invest in the use of technology was frequently mentioned by participants, particularly the willingness to commit to a personal effort so that a device could be used. A low willingness to invest effort was related to not wanting to use new technology: 'Then I have to make an effort and use my brain... I am too… I think I have so much to do already' (P23), but also to abandoning previously used technology. Besides the willingness to invest effort, participants mentioned the willingness to invest financially and the opportunity cost of such an investment. An example is that of a woman who chose to have her hearing aid repaired rather than doing something else with her money: 'No, no, because I guess I just won't go on vacation for a year' (P46).

In addition to attitudes, participants also expressed various pre-usage and post-usage technology-related beliefs. These could be categorized into three sets. The first set of beliefs was related to how participants evaluated the properties of a technology. These included weight (being heavy or light), size (being large or small), average battery life, radius of action, reliability, lifespan, amount of power consumption, esthetics, and cost of purchase or maintenance. Particularly when participants did not use a certain type of technology, they would mention a relatively large number of properties that they perceived as unfavorable.

The second set of beliefs entailed the consequences of using technology, which could either be positive or negative. Perceived consequences could involve personal consequences for the participant, or consequences for other people. Regarding the consequences for other people, participants showed that they were concerned for people in their social network. For example, participants stated that they used a personal alarm button because it provided reassurance to their children. Or, participants mentioned that they did not want to burden their children when using modern technology that proved problematic to them: 'My daughter has little knowledge of computers. Her husband does, but I don't want that. I don't want to burden them' (P16). In regard to the personal consequences of technology use, participants regularly mentioned that they expected or experienced advantages that were in line with what the technology was designed for, such as the ability to prepare food, do household tasks, or stay informed. Sometimes participants mentioned that technology enabled them to perform certain tasks more efficiently, such as using a tumble dryer that speeds up the process of drying clothes. Participants frequently spoke about what technology did or could do to their quality of life, more specifically their health, their level of comfort, the quality of their social contacts and their safety. When it came to safety, participants felt technology, for instance, using a mobile phone, could impact their physical safety: 'Yes, I think it is important to keep it with me, it gives me a sense of security. The feeling that I can reach someone when I need to' (P46). However, they also felt technology could impact their digital safety, and many participants had concerns regarding their privacy and computer crime. Participants also talked about how the use of technology would make them feel frustrated, happy, entertained, useful, tired, stressed, or relaxed. However, technology could also make them feel old, and a number of participants acknowledged that this feeling prevented them from starting to use assistive technology, such as a personal alarm button: 'I don't want them to see me as an old lady who cannot do anything anymore' (P14). Whether or not the use of technology could have consequences for their ability to live independently was something that was hardly brought up by the participants. Many participants did express a fear of becoming too dependent on technology or being 'addicted' to technology.

The third set of technology-related beliefs was concerned with the participants' perceived personal proficiency in operating technology. Participants made references to their (in)ability to use certain types of technology, particularly entertainment appliances, ICT, smartphones, and microwave ovens. For example, some of the participants who also participated in the tablet computer pilot project had never owned an ICT device. These participants feared a steep learning curve and stated that they would need assistance. In these cases, technology self-efficacy was low: 'It's giving me a stomach ache already… What am I supposed to do with it? I don't know if I can do this' (P1). On the other hand, participants who did have experience in using ICT were more confident: 'I'm used to all of that, which makes a huge difference' (P2). When discussing technology, several participants compared their technology proficiency unfavorably with that of younger adults, and some participants were hindered by a lack of proficiency in the English language. Frequently participants would state that

they needed to regularly practice using technologies: 'Look, it's been explained to me… But I keep forgetting how to use it whenever I've not used it for several weeks' (P30). Others stated that they could not use technology due to physical limitations, such as osteoarthritis or poor vision.

Influence of the Social Network

As mentioned in the previous paragraphs, members of the social network of the participant can act as an alternative to the participant's personal technology use, and participants were concerned how their technology use affected other people in their social network. In addition, the social network played three other, more direct, roles in influencing the participants' use of technology and their technology-related attitudes and beliefs. First, people who were in close contact with the participant could recommend or advise against certain technologies. An example is this interaction between a participant and her grandson: '… And then he said to me: "You have to, grandma, you have to install Skype, so I can see you. Before, I visited you, but now I don't see you anymore." I said: "Son, let's do that."' (P32). In other cases, advice was offered by the participants' children, their partner, other relatives, and peers.

Second, members of the social network offered support that facilitated the use of technology. Very frequently, participants were accompanied by younger relatives when they bought entertainment appliances, ICT devices, phones, or household appliances. These relatives would help participants in deciding what to buy, and frequently installed or configured newly bought devices. Often, they would also show participants how to use modern technology and write small notes containing instructions on how to operate devices. In many cases, children, grandchildren and sons-in-law were there to fall back on: 'I: Do you have any doubts or concerns regarding the iPad? P: No, I don't think about that because I go to my son-in-law whenever I have any concerns or troubles' (P01). Support from the social network was appreciated, yet several participants complained that younger adults explained things 'too quickly' and stated that this prevented them from asking for assistance on future occasions. Sometimes, relatives also bought technology for the participant. When this occurred, several participants reported a mismatch between what their relatives thought they needed and their personal perception of what they would need.

Lastly, members of the social network were also users of technology, and in their role of co-user they influenced the use of technology by participants: 'I: Are there any other reasons why you started using a computer? P: I saw how my daughters and my grandsons used their computer… And I wanted to do what they did, I thought it was magnificent' (P9). Participants also mentioned that they tried out technology when they were visiting members of their social network, and that this contributed to them starting to use it themselves. Furthermore, the use of communication technology by participants was induced and maintained by family members, who frequently e-mailed, texted or called participants.

Influence of Organizations

The use of technology and technology-related attitudes and beliefs were also influenced by technology suppliers, home care providers, and agencies that could provide financial compensation. Regarding the role of the technology supplier, participants frequently mentioned that they saw a special offer which was the 'final trigger' that led them to buying a new technology. Also, participants acknowledged that they were susceptible to advertising: 'When they advertise that much, I expect it to be something special' (P31). However, participants had a strong preference for buying technology in a local store that they knew, instead of shopping online. Some participants stated that they were more likely to buy a technology when they could try it out first. Moreover, some of the participants stated that they were dissatisfied with the technical support which was included in a service, for example in the tablet computer pilot project, and that this played a role in their discontinued use of that particular technology. In discussing entertainment appliances and ICT, several participants regretted the fact that the technology supplier did not provide a step-by-step manual. Home care providers and care funding agencies only played a role in the use of assistive technologies. Participants would frequently state that they received financial compensation from insurance companies or other agencies, such as municipalities. Some of the participants disclosed that they were worried about whether they would receive financial compensation for their assistive device in the future: 'This one was completely reimbursed, but I don't know what will happen in the near future' (P35). Occasionally, a participant complained of a lack of knowledge of assistive devices on the side of home care professionals.

Role of the Physical Environment

Participants commented on the physical environment, and this appeared to influence their use of technology as well as their technology-related attitudes and beliefs.

First, they rejected computers, or other modern technologies that were considered too intrusive: 'I feel it is too intrusive in a living room... I do not like that' (P18). Second, it became clear that rarely used technology was frequently stored in places that were hard to reach, or rooms that were not visited regularly. An example of this is a participant who at the end of the visit remembered that she had a tablet computer stowed away somewhere, which she only used rarely to play games. Lastly, participants mentioned that they were reluctant to buy technology which took up a lot of space or forced them to make adjustments to their home.

In addition, participants spoke about circumstances outside of their homes. When discussing mobility aids and means of transport, several participants mentioned that they were worried about road safety, and that this kept them from using those types of technology: 'I: You would rather let yourself be transported? P: Yes, fewer accidents. The risk of accidents is too high at my age' (P50). Other problems included a lack of proper parking facilities and low accessibility of buildings. Weather conditions were frequently mentioned as a factor which influenced the use of means of transport. However, weather conditions also affected the use of ICT, according to a number of participants who stated that they primarily used their computer when the weather was bad: 'When the weather is nice I want to be outside' (P10).

Discussion

The results clearly show a considerable amount of variation among participants regarding ownership and level of use of technology. An effort was made to explain and describe these differences in themes and in a comprehensive model. Our findings indicate that participants face several challenges in the domain of independent living, yet the use of technology to participants was just one of several options. Often, participants would state that they did not have to use a technology because they could rely on alternatives. The availability of alternatives and the processes involved in considering these alternatives have been largely overlooked in previous studies on technology acceptance by older adults, possibly because alternatives are not part of frequently employed models of technology acceptance [18, 19]. However, the role of alternatives is recognized in models of health care utilization [29] and consumer behavior [30, 31]. The current study indicates that alternatives are also relevant in explaining and understanding technology use. With regard to the role of alternatives it is important to note that older adults may be unaware of technological solutions that could benefit them [30].

According to our results, the participants' use of technology was to a large extent influenced by their pre-usage and post-usage technology-related attitudes and beliefs. This is in line with the existing body of research on technology acceptance by community-dwelling older adults [8, 12, 16, 32–34]. Recently, qualitative studies were performed in Hong Kong [33] and in England [34]. Similar to our study, the results of these studies indicate that acceptance of technology by community-dwelling older adults is influenced by perception of the properties of technology, perceived consequences of using technology, perceived personal proficiency in using technology, perceived need for technology, and the willingness to invest effort in using technology. The aforementioned factors are at the heart of our conceptual model.

Participants in the current study regularly perceived technology as having both favorable and unfavorable consequences simultaneously, which is also in line with previous research [32, 35]. Many participants did not see technology as a means to enable or sustain independence, although they did experience benefits in domains of which research shows that they are important to independent living, e.g., the ability to perform daily tasks, communicate with others, and stay physically active [24, 36].

The current study also points to the important role of external influences. The social network of participants influenced the participants' use of technology as well as their technology-related attitudes and beliefs, by offering advice, by providing support, and by acting as a co-user. Support and proper coaching may be essential to the adoption of technology by older adults [16, 37], however, participants and members of their social network did not always agree on the need for technology. Additionally, participants were hesitant to put a burden on others by using technology. This is in line with previous research on technology acceptance by community-dwelling older adults [33, 34], as well as research pointing to the importance of relatives to older people, and the complex nature of family ties [38]. All in all, our research shows that the adoption of technology to a substantial extent is 'a social process, even more than a technical matter' [39]. This is largely overlooked by classical technology acceptance models [18, 19] that have reduced social influences to the construct of a subjective norm (i.e., a person's perception that most people who are important to him think he should or should not use technology). Our research also shows that the use of technology by participants was in-

fluenced by the actions of technology suppliers, home care providers, and agencies that provide financial compensation. The integration of the role of these organizations in our model is in line with a call by Lee and Coughlin [12] to pay more attention to the interactions between older users and organizations concerned with the delivery of technology. Lastly, the participants' use of technology was influenced by how well technology fitted within their homes, and how their technology use matched with the physical environment outside their homes. This is partly in line with previous research, in which older adults mention that they are wary of technology that they consider too obtrusive within their homes [40, 41]. These findings also support appeals from the fields of health geography [42, 43] and environmental gerontology [44] to integrate the physical environment in studies concerned with aging individuals.

All in all, our results show that older adults' perceptions and use of technology are embedded in their personal, social, and physical context. Insight into the context of aging in place is crucial to the understanding of why, how, and when community-dwelling older adults are using technology. While the current study enabled us to produce a comprehensive conceptual model of factors influencing acceptance, the current model needs to be seen as a first step. The current design did not allow us to determine the strength of the relationships between factors, nor did it allow us to determine moderating or mediating relationships between factors. Looking at our model, several areas could benefit from further exploration. In particular, the current model is not exhaustive with regard to how organizations such as technology suppliers and home care providers facilitate and impede the use of technology by community-dwelling older adults. Additionally, more research is needed to better understand how older adults evaluate and decide between the various (technological) options that are available to them, when faced with challenges in the domain of independent living. Although it was not the goal of the study, the current design also did not enable us to structurally differentiate how factors differ between the included types of technology and stages of use. Additionally, many of the phenomena described in our findings are subject to change over time, and research exploring longitudinal mechanisms influencing technology use is required to better understand the dynamics, interplay, and relative importance of factors. More specifically, longitudinal research is needed on how changes in the personal context (i.e., needs, activities, and health status) and the social context (i.e., actors and roles in the social network) affect community-dwelling older adults' attitudes and beliefs with regard to using technology.

It is important to note that our findings are affected and possibly biased by our beliefs, values, and assumptions. We addressed this issue by working in alternating pairs during data collection and analysis, and by critically evaluating the design and findings in group discussions involving all the authors. Furthermore, the results in our study are susceptible to recall bias, since the interviews were retrospective to some extent. Congruent with the explorative nature of the current study, our sample was heterogeneous in terms of background characteristics and included both users and nonusers of various types of technology. Three participants did not meet the inclusion criterion of being 70 years or older, which is why we conducted a post hoc analysis to see if our findings would have been different if we had not included these 3 participants, and this was not the case. Moreover, we still managed to include a relatively old group of participants. Although our sample was large compared with other qualitative studies [45], and our results are in many ways similar to studies in different contexts [33, 34], survey research is necessary to determine if our results can be generalized.

As the worldwide population of older adults living with chronic diseases grows, there have been calls to look at health in terms of 'the ability to adapt and self-manage in the face of social, physical and emotional challenges' [46]. In light of these developments, the role of technology is becoming increasingly important, not only because it could provide older individuals with the means to adapt and self-manage, but also because using technology requires adaptation and self-management by older adults themselves. Our results show that acceptance of technology while aging in place is highly dependent on the older individuals' specific personal, social, and physical context. This implies that older adults' acceptance of technology is not just about the technology itself. Policy makers, technology suppliers, professional caregivers, and family members who aim to support aging in place through the use of technology need to take into account a number of psychological and contextual factors when introducing or implementing technology. Furthermore, since older adults constitute a very heterogeneous group [47], a one-size-fits-all approach is unlikely to succeed. Our conceptual model provides an overview of key areas to address. For example, family members and professional caregivers who feel the need to discuss the use of technology with older adults can employ the topics in our model to fuel this discussion. Additionally, technology suppliers and policy makers can use our model as a framework for stim-

ulating and monitoring conditions that are favorable for the use of technology by older adults. While there might be a tendency to try to directly influence older adults' technology-related attitudes and beliefs, the uptake of technology might also be improved by optimizing the context in which it is intended to be used. The current research indicates that the role of the close social network is particularly important. Although technology is often seen as a way to partly replace the social network, our research shows that the social network is often crucial for older adults to be able to initiate and sustain their use of technology. In conclusion, technological interventions intended to support aging in place need to consider and address older individuals' specific personal, social, and physical context. In this pursuit, the described model can be used as a starting point.

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