Understanding technology acceptance by older adults who are aging in place

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Understanding technology acceptance by older adults who are aging in place: a dynamic perspective

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Contents

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General introduction

"The question persists and indeed grows whether the computer makes it easier or harder for human beings to know who they really are, to identify their real problems, to respond more fully to beauty, to place adequate value on life, and to make their world safer than it now is" [1].

As expressed in this 1966 quote by Norman Cousins, modern technologies fuel both hope and discussion. Hope, because of the potential they offer. And discussion, due to concerns that exist regarding their design and application. This also pertains to technologies that are designed to facilitate independent living in the community by older adults, also referred to as aging in place [2]. Most older adults prefer to age in place [3–6]. However, several interrelated factors can challenge the independence of older adults, primarily functional and cognitive impairment, chronic diseases, a diminishing social network, and a low level of physical activity [7–10]. Various types of technologies potentially could help independent-living older adults in facing challenges while aging in place, by supporting or enhancing personal health and safety, mobility, communication, activities of daily living, and physical activity [11]. Specific examples of technologies include vital signs monitoring and fall detection devices, mobile phones specifically designed for seniors, and electronic medication reminders [12]. Additionally, there are generally available consumer appliances and devices that can play a role in staying independent, active and healthy (e.g., fitness equipment to stay physically active, home appliances for activities of daily living, and information and communication technologies to support social contact) [13,14]. Policy makers hope that the aforementioned technologies can improve quality and length of life of an aging population, while also relieving pressure on increasingly stretched health and social care services [15,16]. Worldwide, the effects of aging are expected to be profound. In developed regions, 24% of the population is already aged 60 years or over, and that proportion is projected to reach 29% in 2030 and 33% in 2050 [17]. Globally, the number of people aged 80 years or older is growing even faster. In developed regions, 5% currently is aged 80 years or older. In 2050 this is expected to have doubled to 10% [17]. This population aging has also raised interest among technology companies, who increasingly see older consumers as an attractive market segment [18]. Technology companies hope and expect a growing demand by older adults for new, easy to use, and affordable products and services [19]. It is nowadays common for policy makers and technology companies to link older adults to technology: older people want to live at home, and technological solutions will allow them to do so [20,21]. This line of thinking is also reflected in the works of researchers, and in ambitions of

research funding programs such as the Ambient Assisted Living program in Europe [22]. While concerns are being raised on issues such as privacy and cost, aforementioned stakeholders, in general, appear to be optimistic about the potential for technology to enable aging in place. However, technologies can only prove their potential if they are acquired and used by their intended users, in this case independent-living older adults. Statistics show that more and more older adults use the computer and the Internet [23,24]. Nonetheless, suboptimal adoption rates are reported when it comes to older adults' use of technologies that are designed to support aging in place [25–29]. Consequently, their suggested potential for older adults in promoting independence and aging in place, and thereby, alleviating pressure on (family) caregivers, and decreasing health care expenditure, has not yet reached its full potential. As the aforementioned illustrates, employing technology to support aging in place is essentially a multi-stakeholder issue. Typical stakeholders include older adults themselves, care professionals, technology designers and suppliers, and policy makers. Several authors have noted that it is crucial to understand what stakeholders' perspectives are, in order for technology to support aging in place to become a success [30–32]. Furthermore, goals and motives of stakeholders may not always be transparent or aligned [16,17]. However, studies providing insight into the convergent and divergent perspectives of stakeholders involved in technology for aging in place are few and far between. The aforementioned has led to the first research question of this thesis:

Research question 1: **What are similarities and differences between the perspectives of older adults and other stakeholders, when it comes to using technology to support aging in place?**

This research question is addressed in Part I of this thesis, which includes Chapters 2 and 3. By conducting focus groups and by reviewing literature, the perspectives of older adults are compared to the perspectives of technology designers and suppliers, policy makers, care professionals, and managers within home care or social work organizations.

Research on technology acceptance by independent-living older adults

The aforementioned issues also highlight the need to develop fundamental knowledge on why and when independent-living older adults acquire and use technologies that could help them to age in place. However, as noted by others, we still do not know very much about when, how and why independent-living older adults acquire and use technology [18,33–36]. The number of scientific

studies that address aging in place and technology is increasing, yet the number of studies that focus on the perspectives of older adults themselves is still modest [33,37]. Previous studies indicate that older adults can see the potential of technology, but acquiring and using technology can also be stressful, and their experiences in using technology can be ambivalent [36,38]. Interestingly, perceived benefits do not 'automatically' translate in acceptance of technology. This can be illustrated by a study by Claes and colleagues that investigated older adults' beliefs regarding contactless sensors [39]. These sensors enable tracking of older adults' personal safety, health status and activities of daily living. According to the vast majority of the participants in this study, contactless sensors were indeed useful for aging in place. However, only a minority of respondents was willing to accept contactless monitoring at this point in their life (15.5 percent). Participants did express a willingness in using technology later in life (82.4 percent), or in the case of health decline (91.8 percent) [39]. These results are typical: many older adults feel that supportive technology is not necessarily fitting for them, but rather for other, less healthy older people. Moreover, there is a serious lack of longitudinal studies that could actually see if reluctant older adults are indeed more willing to use technologies as they grow older and become less healthy [40–43]. Since older adults form a heterogeneous group [44–46], it appears important to understand what circumstances, personal characteristics and developments lead to use and non-use.

However, researching the abovementioned is hampered by limited theoretical development on the relationship between independent-living older adults and technology [16,26]. Others have noted that there is a need for technology acceptance studies to move beyond merely describing facilitators and barriers to technology uptake [26]. The field of gerontechnology (i.e., gerontological research that addresses technology) has been described as *"almost devoid of theory"* [16]. When theories are being used to study technology acceptance by older adults, researchers often turn to the Technology Acceptance Model (TAM) [47], and the Unified Theory of Acceptance and Use of Technology (UTAUT) [48]. Both models originally were aimed at explaining technology (non-)use by individuals working in organizations. The main predictor variables in TAM are perceived usefulness and perceived ease of use. Systematic reviews have shown that these two variables typically explain 40 percent of an individual's intention to use a technology in a variety of contexts including healthcare [49–51], and that intention to use may [52], or may not [53] predict actual use of technology. UTAUT is employed less, but can explain up to 70 percent of

intention to use at the expense of parsimony, by including two additional predictors (social influence and facilitating conditions) and four moderating variables (gender, age, experience and voluntariness of use) [54–56]. There also exist later versions of these models such as TAM3 that mainly adds various antecedents to perceived usefulness and perceived ease of use, and UTAUT2, that adds price value, habit and hedonic motivation [57,58]. While being powerful and robust, TAM and UTAUT have also received criticism. Technology acceptance researchers have pointed out that both models do not take into account that technology acceptance factors may fluctuate over time [40,41,59–61]. This makes it difficult to use these models to conduct much desired research on the link between age-related changes and technology acceptance processes [26]. Equally important: recent reviews of studies involving older adults have indicated that TAM and UTAUT are missing essential predictors of technology use that are specific to independent-living 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) [62,63]. The aforementioned gaps in the current literature have informed the second and last research questions of this thesis:

Research question 2: **Which factors influence ownership and use of technology by older adults who are aging in place?**

This question is addressed in Part II of this thesis. In chapter 4, results of a systematic literature review are reported. The next chapter reports findings of qualitative explorative field research. In chapter 5, older adults' reasons for using technology while aging in place are explored. Lastly, the role of family members is examined in chapter 6.

Research question 3: **How do changes and developments in the lives of older adults influence their acquirement and use of technologies?**

Part III presents a dynamic perspective on acquirement and use of technologies by independent-living older adults. Results of longitudinal qualitative field research are presented. Chapter 7 investigates the origins and consequences of technology acquirement, and chapter 8 is concerned with changes and stability in the use of technologies over time.

As such, this thesis represents a body work that is concerned with understanding older adults' perspectives and experiences on acquiring and using technology while aging in place. The empirical studies in this thesis mainly involved people aged 70 or older, since older age is related to both increased difficulty to age

in place [7] and less use of technology [48,62,64]. Chapter 2, and chapters 4 to 8 were written as articles for publication in international scientific journals. Chapter 3 was written as a chapter for a scientific book. All chapters can be read independently of each other, although there is inevitably some overlap. This thesis ends with a general discussion in Chapter 9 in which main findings, strengths and limitations, and recommendations and implications for research and practice are presented.

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PART I

Stakeholders' perspectives on using technology to support aging in place

2

What it takes to successfully implement technology for aging in place: focus groups with stakeholders

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Abstract

Background There is a growing interest in empowering older adults to age-in-place by deploying various types of technology (i.e., eHealth, Ambient Assisted Living technology, Smart Home technology, and Gerontechnology). However, initiatives aimed at implementing these technologies are complicated by the fact that multiple stakeholder groups are involved. Goals and motives of stakeholders may not always be transparent or aligned, yet research on convergent and divergent positions of stakeholders is scarce. **Objective** To provide insight into the positions of stakeholder groups involved in the implementation of technology for aging-in-place; what kind of technology do they see as relevant, what do they aim to achieve by implementing technology, and what is needed to achieve successful implementations? **Methods** Mono-disciplinary focus groups were conducted with participants (N = 29) representing five groups of stakeholders: older adults (n = 6), care professionals (n = 7), managers within home care or social work organizations (n = 5), technology designers and suppliers (n = 6), and policy makers (n = 5). Transcripts were analyzed using thematic analysis. **Results** Stakeholders considered 26 different types of technologies to be relevant for enabling independent living. Only six types of technology were mentioned by all stakeholder groups. Care professionals mentioned fewer different types of technology than other groups. All stakeholder groups felt that the implementation of technology for aging-in-place can be considered a success when: (1) older adults' needs and wishes are prioritized during development and deployment of the technology; (2) the technology is accepted by older adults; (3) the technology provides benefits to older adults; and (4) favorable prerequisites for the use of technology by older adults exist. While stakeholders seemed to have identical aims, several underlying differences emerged, for example with regards to who should pay for technology. Additionally, each stakeholder group mentioned specific steps that need to be taken to achieve successful implementation. Collectively, stakeholders feel they need to take the leap (i.e., change attitudes, change policies, collaborate with other organizations); bridge the gap (i.e., match technology with individuals, stimulate interdisciplinary education); facilitate technology for the masses (i.e., work on products and research that supports large-scale rollouts, train target groups on how to use technology); and take time to reflect (i.e., evaluate use and outcomes). **Conclusions** Stakeholders largely agree on the direction in which they should be heading; however, they have different perspectives with regards to the technologies that can be

employed, and the work that is needed to implement them. Central to these issues seems to be the tailoring of technology or technologies to the specific needs of each community-dwelling older adult, and the work that is needed by stakeholders to support this type of service delivery on a large scale.

Introduction

A key challenge for most, if not all, countries is how to accommodate and care for an aging population [17]. As a response, many countries have shifted their priorities and resources towards deinstitutionalization in order to create communities that facilitate seniors to remain living in their homes for as long as possible [37]. Policies and programs that represent this paradigm shift frequently emphasize the deployment of technology as a means of supporting aging-in-place. Examples of technologies mentioned are sensor-based networks for activity monitoring, emergency help systems, and online tools to support older adults' self-management of chronic conditions [11,65]. These technologies are often ICT-based, and are referred to as eHealth, Ambient Assisted Living technology, Smart Home technology, and/or Gerontechnology. Unfortunately, the implementation of these technologies is frequently unsuccessful in daily practice [28,46,66].

Several factors hinder the implementation of the aforementioned technologies, including low adoption levels among potential users [11,46,65,67], difficulties in building sustainable business cases [68,69], a lack of interoperability between systems of different vendors [66,68,70], and scarcity of robust scientific evidence on cost and outcomes [71–73]. All the aforementioned factors are complicated by the fact that multiple stakeholders are involved [68,74]. Typical stakeholders include older adults, care professionals, managers within home care or social work organizations, technology designers and suppliers, and policy makers. The goals and motives of these groups of stakeholders may not always be transparent or aligned [75,76]. However, empirical studies providing insight into the convergent and divergent perspectives of stakeholders involved in implementing technology that could support aging-in-place are few and far between. Furthermore, the few existing studies limit their focus on perceived barriers to a successful implementation [77,78] rather than forming a more complete understanding of stakeholders' positions. For example, several authors have noted that it is crucial to understand what the different stakeholders' goals are in initiatives centered around supporting aging-in-place with technology [30–32]. Hence, the current study seeks to provide insight

into the positions of stakeholder groups involved in the implementation of technology for aging-in-place: What kind of technology do they see as relevant for aging-in-place? What do they aim to achieve by implementing technology? What is needed to achieve successful implementations? A better understanding of the positions of various stakeholder groups is expected to contribute to the successful implementation of technological interventions aimed at supporting aging-in-place [30,70,79,80].

Methods

Participants

The current study was conducted in the Netherlands. In 2012, our research group, in collaboration with thirteen partners, initiated a project aimed at finding ways to successfully deploy technologies that could support aging- in-place, by conducting a longitudinal field study among community-dwelling older adults. As a part of the project, five mono-disciplinary focus groups were conducted simultaneously with participants representing five groups of stakeholders within the process of implementing technology for aging-in-place: older adults, care professionals, managers within home care or social work organizations, technology designers and suppliers, and policy makers. These focus group sessions took place in February 2012, and convenience sampling was used by the partners of the project to recruit participants. This means that participants in the focus groups were either working for one of the partners in the project or were professional relations of partners. At the time the focus group sessions were conducted, participants representing different stakeholder groups were not engaged in implementing technology for aging-in-place together. Mono-disciplinary focus groups were employed, because this data collection method was expected to efficiently enable productive discussions and the elicitation of a multiplicity of views by each stakeholder group [81]. Furthermore, we wanted to provide a safe environment for participants [81].

Procedure

Focus group sessions took place simultaneously in the Fontys Institute of Allied Health Professions, which is located in Eindhoven, The Netherlands. Sessions lasted 90 minutes, and each session was supervised by a moderator and an assistant. Moderators had a professional background that was related to the background of the participants in their session. At the beginning of the sessions, a scenario was read out loud by the moderators. The scenario

described how population aging increases the need for creative solutions to be able to continue to provide good quality care for older adults. Furthermore, the scenario explained that more and more older adults are expected to age in place, and that technological solutions are expected to play an important role in this respect. In the group discussion that followed within each session, three open-ended questions were discussed by participants. First, participants were asked what kind of technologies they considered as 'technologies that could support aging-in-place'. This question was asked to make transparent what stakeholders perceived as technology relevant to the context of aging-in-place. Second, participants were asked when they would consider the use of technology for aging-in-place a success. This was asked to determine what stakeholders are trying to achieve with regards to the implementation of technology for aging-in-place. Third, participants were asked what they need to be able to successfully implement technology for aging-in-place, and what they can contribute in order to achieve successful implementations. This was done to let participants reflect on their role as stakeholders. After each question, participants were requested to first write down their answers on a form to enable them to collect their thoughts prior to engaging in the discussions. Informed consent was acquired from all participants, and each session was recorded on audio and video to enable transcription. Transcriptions were made anonymous, and all data was only used in the current study. Dutch law does not require medical or ethical reviews for focus group interviews with stakeholders other than patients. All moderators were trained according to guidelines described by Sim [81] and provided with a guide that was produced by the lead author. Each moderator was accompanied by an assistant who took notes, and aided in facilitating an open dialogue between group members. Immediately after the sessions, the moderators and assistants gathered to evaluate. The moderator and assistant of the session that consisted of technology designers and suppliers stated they had to intervene regularly, because some participants were dominant in the discussion, and because participants needed to be reminded to reflect on their own role, instead of focusing on the role of other stakeholders. Moderators and assistants of the other group sessions did not experience these issues, or to a far lesser extent.

Analysis

Verbatim transcripts of the sessions were analyzed using thematic analysis [82]. First, inductive codes were attached to quotations relevant to the research questions. In this process, each transcript was initially coded independently

by two researchers, who subsequently had to come to an agreement and produce a single coded version of each transcript. Afterwards, overarching categories of codes (i.e., themes and subthemes) were formed. Additionally, the technologies that the participants deemed relevant for aging-in-place were classified in application domains that are part of the Gerontechnology taxonomy as proposed by van Bronswijk, Bouma and Fozard [83]. This taxonomy was selected because it is targeted towards technologies that are relevant to older adults, and because it allows for the inclusion of a wide range of technologies, which is in line with the participants' responses. As a member check, a separate meeting was organized in which preliminary findings were presented. In this way, participants were provided with the opportunity to learn more about the positions of the various stakeholder groups involved in the project. Two-thirds of the participants attended the meeting, and they accepted the presented findings as accurate and complete.

Results

A total of 29 participants were involved in the study, and each stakeholder group was represented by five to seven participants (see Table 1). Participants were 32 to 76 years old, and the average age was highest in the focus group with older adults. The managers in the study were all women. Care professionals were predominantly women, while technologists were predominantly men.

Table 1. Stakeholders and participants involved in mono-disciplinary focus groups (N = 29)

Stakeholder	Description of participants	Participant characteristics	n
Older adults (O)	Community-dwelling older adults (active in community voluntary work)	Three men and three women, aged 62 – 76 years	6
Care Professionals (C)	Care professionals who provide home care themselves, or coordinate the provision of home care	One man and six women, aged 32 – 55 years	7
Managers (M)	Managers within home care or social work organizations	Five women, aged 37 – 61 years	5
Technologists (T)	Professionals who work for companies that produce and supply technology, or for education institutions with a focus on technology	Five men and one woman, aged 36 – 66 years	6
Policy makers or advisors to policy makers (P)	Public officers, and advisors and researchers involved in health policy	Three men and two women, aged 32 – 61 years	5

Types of technology that could support aging-in-place

Stakeholders had a broad view with regards to technology that could support aging-in-place, which in their eyes included hardware, software, or combinations of both. In addition, technologies that are not based on ICT were mentioned (e.g., consumer appliances, home adaptations). The technologies that were mentioned can be classified in application domains that are part of the Gerontechnology taxonomy [83]: health and self-esteem, housing and daily living, mobility and transport, communication and governance, and work and leisure (see Table 2).

Table 2. Technology believed to play a role in supporting aging-in-place according to stakeholder groups, categorized in application domains as proposed in the Gerontechnology taxonomy [83]

Application domains	Technologies	O	C	M	T	P
Health and Self-esteem	Health monitoring	X	X	X	X	X
	Personal alarms	X	X	X	-	X
	Physical activity stimulation	X	-	-	X	X
	Fall detection	-	X	X	-	X
	Medication reminders	-	-	X	X	X
	Wandering detection	-	-	X	X	-
	Online questionnaires	X	-	-	-	X
	Lifestyle monitoring	-	-	-	X	-
Housing and Daily Living	Assistive technology	X	X	X	X	X
	Home automation	X	X	X	X	X
	Household appliances	X	X	X	X	X
	ADL Robots	X	-	X	X	X
	Electronic agendas	X	-	-	-	X
	Home adaptations	-	X	-	X	-
	Lift assist devices	-	-	-	X	-
Communication and Governance	Computers	X	X	X	X	X
	Video telephony	X	X	X	X	X
	Caregiver e-collaboration	X	-	X	X	X
	Electronic Health Records	X	-	X	-	-
	Social media	-	-	X	-	X
	Telephones	X	-	X	-	-
Work and Leisure	Television and radio	X	-	X	-	X
	E-readers	X	-	-	X	-
	Games	-	-	-	-	X
Mobility and Transport	Transportation devices	X	-	X	X	-
	GPS navigation	-	-	-	X	-

X, mentioned by stakeholder group; –, not mentioned by stakeholder group
O, Older adults; C, Care professionals; M, Managers; T, Technologists; P, Policy advisors and policy makers

In total, 26 different technologies were mentioned by stakeholders across the five domains of the Gerontechnology taxonomy. These technologies for the most part fall under the domains of health and self-esteem (n=8), housing and daily living (n=7), and communication and governance (n=6). Five technologies fall under the domains of work and leisure or mobility and transport. Care professionals in total mentioned nine different types of technology, while the other stakeholder groups each mentioned 17 different types. Six technologies were mentioned by all stakeholder groups (health monitoring, assistive technology, home automation, household appliances, computers, and video telephony), while three technologies (lifestyle monitoring, lift assist devices, and GPS navigation) were mentioned by one stakeholder group - the technologists. All other technologies were mentioned by two, three or four stakeholder groups.

Opinions on what constitutes a successful implementation of technology

All stakeholder groups considered the implementation of technology for aging-in-place a success when: older adults' needs and wishes are prioritized during development and deployment of technology, the technology is accepted by older adults, the technology provides benefits to older adults, and favorable prerequisites for the use of technology by older adults exist (see Table 3). According to the participants, the aforementioned four major themes (user-centeredness, acceptance, benefits, and prerequisites) are interrelated. All stakeholder groups stressed the importance of taking the perspective of older adults into account, and there was a shared belief that such a user-centered approach would have a positive effect on the acceptance of technology, on the benefits technology can provide, and on the existence of favorable conditions for technology use. Moreover, there was a common belief that technology can only provide benefits to older adults when it is accepted by them, and that acceptance of technology is dependent on certain prerequisites that need to be in place. A typical example of this notion is: *"Low ease of use leads to non-use and a lack of added value"* (P5).

Table 3. Stakeholders' perspectives on what constitutes successful implementation of technology for aging-in-place: major themes, subthemes and typical quotations

Major themes	Subthemes	Illustrative quotations	O	C	M	T	P
User-centeredness Older adults' needs and wishes are given priority during development and deployment of the technology, meaning …	…the technology is in accordance with each older adult's specific needs.	"What's needed is a solution for what the individual thinks is a problem, not what we consider a problem" (P4)	X	X	X	X	X
	… older adults are in control.	"So that it's not the technology that controls my life, but rather it's me controlling the technology" (O6)	X	X	X	-	-
	… older adults' privacy is treated with respect.	"Seniors shouldn't get the feeling they're being followed or watched" (C6)	X	X	-	X	-
Acceptance The technology is accepted by older adults, meaning …	… older adults enjoy using the technology.	"A positive experience, causing people to use it again" (M1)	X	X	X	X	X
	… the technology is used on a regular basis.	"When technology is actually being used" (P3)	-	X	X	X	X
	… older adults are proud to use the technology (instead of ashamed).	"It shouldn't be stigmatizing" (O6); "I feel we should aim to create a hype" (M4)	X	-	X	X	X
Benefits Use of the technology provides benefits to older adults, meaning …	… the technology improves the quality of life of older adults.	"When the client or individual experiences that his or her quality of life remains the same or increases markedly" (M5)	X	X	X	-	X
	… the technology supports independent living.	"If no one needs to go to a nursing home" (T2)	-	X	X	X	-
	… the technology provides reassurance.	"Causing people to find an answer to a slowly rising fear of being unstable, frail. (T5)	X	X	-	X	-
Prerequisites Favorable prerequisites for ownership and use of technology by older adults exist, meaning…	... the technology is easy to use.	"The technology must be extremely user-friendly" (M2)	X	X	X	X	X
	… the technology is affordable.	"Affordability continues to be a problem" (T6)	X	X	X	X	X
	... the technology is reliable.	"It must work, it must be reliable" (O3)	X	X	-	X	-
	… technical support is available.	"The supplier or care organization must provide good service" (O3)	X	X	-	-	X

X, mentioned by stakeholder group; –, not mentioned by stakeholder group
O, Older adults; C, Care professionals; M, Managers; T, Technologists; P, Policy advisors and policy makers

Looking at the first major theme (user-centeredness) and its underlying subthemes, all stakeholder groups found it important that technology is in line with the needs of each specific older individual. For example, older adults and policy makers mentioned that technology should not stand in the way of human contact. User-centeredness was also reflected in the fact that stakeholders mentioned that older adults need to be in control over technology instead of the other way around, and that the privacy of older adults needs to be treated with respect. However, policy advisors, care professionals and older adults also stated that individual differences can make it difficult (or expensive) for technology to meet older adults' needs in every situation: *"It's very hard to achieve this technically … how many diseases are there, and how many different impairments? Think about it" (O4).*

The second major theme (acceptance) implicates that older adults enjoy using the technology, and that they use it on a regular basis. It also means that older adults are proud to use technology. The latter point reveals a difference of tone between stakeholder groups: older adults stressed the importance of not feeling ashamed or stigmatized, while managers, technologists and policy advisors talked in terms of taking pride: *"It's okay to have it in your home and show it to visitors: 'look what I have! '... it's not all bad when you grow older, of course you want to show off the nice things that you have"* (T_3).

With regards to the third major theme (benefits) and its underlying subthemes, stakeholders felt that technology needs to improve older adults' quality of life, support their ability to live independently, and provide reassurance (i.e., enhance safety). However, care professionals, managers, and policy advisors stressed that other stakeholder groups are also involved in using technology for aging-in-place: *"People often look at older adults as being the end user. However, informal and professional caregivers are also end users"* (P2). According to managers, this implies that professional caregivers need to see the benefits of employing technology as well. Older adults felt that technology should provide benefits, but also that technology should not make life too easy: *"I think that technology should not make people lazy. For instance, mobility scooters - with all due respect for people who need them- are being used too easily, causing people to walk less"* (O6).

The fourth major theme (prerequisites) entails the existence of conditions favorable to technology use and ownership. More specifically, stakeholders mentioned that technology should be easy to use, affordable, and reliable.

Additionally, technical support should be available, preferably in person: *"I think that there should be a physical location where one can ask something … personal support"* (P5). Especially care professionals and technologists expressed concerns with regards to affordability. Care professionals mentioned that technology in care settings can be expensive, and they worry who would pay for technology. Technologists mentioned that they foresee a trend where older adults themselves are the ones who pay for technology. In this scenario, technologists see older adults' willingness to pay for technology as critical, and they feel that the technology that they wish to sell needs to be more affordable than competing alternatives. In contrast, older adults only fleetingly mentioned the fact that technology needs to be affordable. As for managers, they looked at affordability from a cost-benefit perspective: *"When the financial benefits exceed the investments"* (M1).

What is needed to successfully implement technology for aging-in-place

Looking at their own roles, stakeholders mentioned several things that they need or can contribute to enable successful implementations of technology for aging-in-place. These can be organized in four major themes and eight underlying subthemes (see Table 4).

Table 4. Stakeholders' views on what is needed to successfully implement technology for aging-in-place; major themes and subthemes.

Major themes	Subthemes	O	C	M	T	P
Take the leap	Change in attitude(s)	X	X	X	X	-
	Change in policies	-	X	X	X	X
	Collaborate with other organizations	-	-	X	-	X
Bridge the gap	Match technology with individuals	-	X	X	-	X
	Stimulate interdisciplinary education	-	-	-	-	X
Facilitate technology for the masses	Work on products and research that supports large-scale rollouts	-	-	X	X	-
	Train target groups on how to use technology	X	X	-	-	-
Take time to reflect	Evaluate use and outcomes	-	X	-	-	X

X, mentioned by stakeholder group; –, not mentioned by stakeholder group
O, Older adults; C, Care professionals; M, Managers; T, Technologists; P, Policy advisors and policy makers

The first theme (take the leap) is concerned with what is needed in terms of commitment by stakeholders. Most stakeholder groups emphasized that a change in attitude is needed on their part to achieve successful implementations. For example, older adults mentioned that they can be more assertive. By this, it was meant that older adults can improve in *"Saying what you think, desire and feel"* (O5), and also that older adults are prepared to ask for help. Older adults stated that this is particularly important when talking to technologists. Additionally, older adults mentioned that they sometimes need to be stimulated to use technology, or as one older adult phrased it: *"Pushed gently"* (O6). Reflecting on their own role, care professionals stated that they need to adjust, and accept that things are changing: "*From a caring perspective, I want to help people in person… however, some things are no longer feasible. I feel that a new mindset is needed"* (C7); and *"It's the client who has technology in his home, and we need to become accustomed to it"* (C4). Managers felt that they need to promote the use of technology more. They mentioned that they can initiate pilot projects, which are seen as a way to have care professionals gain experience in using technology. Technologists mentioned that technology companies need to be prepared to take financial risks. More specifically, companies need to have the confidence to produce and roll out technologies on a large scale. For this, a long term strategy and perseverance are required: *"There can be up to 20 years between designing the thing, and starting to make a profit. We have to get used to that, that's the long term vision we have to have"* (T_3).

Additionally, most stakeholder groups proposed that policies need to be changed. Care professionals ask that the organizations which they work for formulate a privacy policy for situations in which technology is employed. Managers stated that they would like more flexibility with regards to the relevant laws and regulations. They also mentioned that they need to incorporate technology in their organizational strategy: *"It all starts at the top, what are the priorities for the organization in the years to come? When technology isn't in there …"* (M5). Reflecting on their own role, policy advisors and policy makers mentioned that a large proportion of technology for older adults is being subsidized, and that the use of these technologies is frequently not sustainable: *"When the funding stops… the technology is no longer used"* (P2). They argue that they need to find ways to counter this unwanted effect of current policies. Some technologists noted that subsidizing technology may obscure the actual needs of potential clients: *"When people receive something for free, I can't make out whether they actually want it"* (t_1).

Furthermore, the need for more organizational collaboration was mentioned

by managers and policy advisors. Managers within home care or social work organizations felt a need to collaborate with others outside of their own organization in order to enable successful implementations of technology for aging-in-place: *"I can't do it alone. I need the municipality, and collaboration with the housing association and welfare organizations. You have to combine forces"* (M4). In this respect, insurance companies, patients associations, and informal caregivers were also mentioned. Policy advisors and policy makers emphasized the importance of international and interdisciplinary collaboration.

The second theme (bridge the gap) entails the work that is needed to connect available technological solutions to the needs of each specific older adult. Care professionals, managers and policy makers stated that help is needed to be able to match technology with individuals. Care professionals mentioned that they would benefit from a 'decision tool'. Such a tool should allow care professionals to find and select the appropriate technology or combination of technologies for each specific client. Ideally, the technologies and aids that are deployed should also be registered in Electronic Health Records. The managers in the study – who worked for different organizations than the care professionals - also mentioned that they would like to provide the care professionals with such a 'decision tool'. Moreover, managers stated they would like to work together with a person (consultant) who knows which technologies are on the market, and who can also match these with the problems older adults face while trying to maintain their independence. Policy makers and policy advisors felt that interdisciplinary education is required to achieve this: *"Because you need to know what an individual needs, you have to understand that person, and subsequently you have to know how to arrange technologies, services, and care"* (P3).

With regards to the third theme (facilitate technology for the masses), managers and technologists discussed the need to engage in large-scale rollouts of technology. Managers stated that there is a demand for technological solutions that can benefit a large proportion of older adults. In their eyes, large-scale rollouts can increase the willingness of commercial companies to invest, which is seen as a requirement for making technology for aging-in-place affordable. In their perception, more research is needed to provide scientific evidence that technology for aging-in-place is effective, and this is also expected to increase support by the government. To be able to conduct large-scale rollouts, technologists mentioned that companies need to do more research in order to gain a more profound understanding of what drives or

impedes technology use by older adults.
Additionally, comments were made with regards to empowering target groups to be able to take advantage of technology. Older adults stated that they need to attend courses to learn how to use technology when they are still healthy enough to attend them. Care professionals also mentioned that they need training to be able to work with the technology. In their eyes, this applies to inexperienced as well as experienced care professionals: *"You have to let yourself get educated, particularly those of us who have been working for a long time"* (C2).

The last theme (take time to reflect) entails the evaluation of use and outcomes. Care professionals mentioned that they see it as their responsibility to regularly evaluate whether the use of technology is appropriate and not too excessive: *"You shouldn't use technology for everything"* (C5). Additionally, policymakers stated that they feel a need to measure whether the use of technology is successful in terms of the desired outcomes. They see it as their role to promote evidence-based solutions.

Discussion

The current study aimed to understand the positions of stakeholders who are involved in the implementation of technology for aging-in-place (older adults, care professionals, managers of care organizations, technologists, and policy makers). It was found that stakeholders considered a multitude of technologies to be relevant for enabling independent living. However, it is important to note that only a small number of technologies were mentioned by all stakeholder groups. Furthermore, care professionals mentioned considerably fewer different types of technology than other stakeholder groups, which is in line with previous research [67]. Additionally, studies have shown that older adults may not be aware of technologies that could be of benefit to them [84,85]. Therefore, when planning and initiating projects concerned with technological solutions for aging-in-place, it is advisable to take into account that stakeholders may have a limited understanding of the scope of available technologies, and that stakeholders may differ in their awareness of available technologies. Moreover, technologies that are not ICT-based (e.g., household appliances and home adaptations) are also relevant in the context of aging-in-place according to stakeholders. In this sense, their concept of technology is less exclusive than the commonly used definitions of Ambient Assisted Living technology [86], Smart Home technology [66], and eHealth [87].

With regards to the aims of stakeholders, all stakeholder groups felt that the implementation of technology for aging-in-place can be considered a success when: (1) older adults' needs and wishes are prioritized during development and deployment of the technology, (2) the technology is accepted by older adults, (3) the technology provides benefits to older adults, and (4) favorable prerequisites for the use of technology by older adults exist. As such, all stakeholder groups were profoundly concerned with the position of older adults when it comes to implementing technologies for aging-in-place. The current study aligns closely with work reported by Greenhalgh et al. [15] in which the authors sought to define quality in the design, implementation and use of telehealth and telecare solutions for older adults with assisted living needs. In this study - which involved older adults, technology suppliers, and service providers - it was concluded that every stakeholder needs to comprehend the (changing) needs and capabilities of older adults, as well as their social context [15]. Such an approach, centered around the older individual, also aligns with the trend towards patient empowerment and patient engagement [88–91]; technology may be used to empower seniors, but this requires their engagement during design and implementation.

While the stakeholders in the current study generally appeared to have identical aims with regards to technology for aging-in-place, it is important to note that underlying differences existed between stakeholders. For example, all stakeholder groups agreed that technology should provide certain benefits to older adults, but older adults were the only group that stressed that technology should not provide too many benefits, since this could make people dependent on technology (which is in line with previous research [43,71,92]). Another example of the variance of opinion is affordability: stakeholders agreed that this is important, but they did not seem to be on the same page with regards to who should pay for the technology. Participants in the current study were not involved in a joint effort to implement technology at the time data for the current study was gathered. Once stakeholders are further in the process of implementing technology together, the aforementioned differences in the interpretation of key aims such as benefits and affordability could lead to cases of 'stakeholder dissonance', which threatens a project's viability if left undetected and unresolved [93].

Each stakeholder group mentioned specific steps that need to be taken to achieve successful implementations. Collectively, stakeholders feel they need to take the leap (i.e., change attitude(s), change policies, collaborate with

other organizations), bridge the gap (i.e., match technology with individuals, stimulate interdisciplinary education), facilitate technology for the masses (i.e., work on products and research that supports large scale rollouts, train target groups on how to use technology), and take time to reflect (i.e., evaluate use and outcomes). Some of the aforementioned steps or recommended actions have also been reported by similar stakeholder groups in other studies, e.g., the need to focus on changing the attitudes of care receivers and care givers [94,95], the need to match technology with individual clients [84,94,96], and the need for training stakeholder groups [67,96,97]. Additionally, studies have pointed to recommended actions that were not mentioned by participants in the current study. These include the need to consider how the introduction of technology affects the existing workflow in home care organizations [94–96], and the fact that care professionals require support while using technology [67,98,99].

The recommended actions brought forward by stakeholders in the current study imply that structural changes need to be made on political/strategic, organizational/contractual, managerial/scientific and operative levels [100]. Such changes will not be easy to implement because of their fundamental character, and because they require changes in how different stakeholder groups operate and interface with one another [15,32,70]. Additionally, recent evaluations of the Delivering Assisted Living Lifestyles at Scale (Dallas) program in England [70] and Scotland [32] indicate that while involving end-users in the design of technologies could promote adoption, it is also very difficult to simultaneously co-design and deliver technologies at a large scale. The reason for this is that co-design is time- and resource consuming [32,70]. This is also demonstrated by Linskell and Bouamrane [101], who describe two possible routes for the delivery of technology that could support aging-in-place; a short and direct delivery route which is prone to misinterpretation of user needs, and a longer co-design route which incorporates task analysis and more extensive specification of product requirements. Therefore, when it comes to matching technology with individuals, the challenge seems to lie in being able to determine when a short and direct delivery route is acceptable, and when a longer co-design route is warranted.

The results of the current study can be viewed in light of Normalization Process Theory (NPT), as described by May and Finch [102–104]. NPT addresses *"the factors needed for successful implementation and integration of interventions into routine work"* [103], and consists of four main components: Coherence (i.e., meaning and sense making by stakeholders); Cognitive participation

(i.e., commitment and engagement by stakeholders); Collective action (i.e., the work stakeholders do to make the intervention function in practice); and Reflexive monitoring (i.e., formal and informal appraisal of the benefits and costs of the intervention) [104]. Our findings seem to indicate that NPT can potentially provide a useful framework for studying implementations in the context of aging-in-place. First, the themes that emerged in the current study with regards to what is needed to successfully implement technology for aging-in-place bear resemblance to NPT's concepts of Cognitive participation, Collective action, and Reflexive monitoring. For example, the 'take the leap' theme (which includes a change in attitudes, a change in policies, and collaboration with other organizations) resembles NPT's cognitive participation component, and the 'bridge the gap' and 'facilitate technology for the masses' themes are in line with NPT's component of collective action. Second, NPT's first component, coherence, includes a "*shared understanding of the aims, objectives, and expected benefits"* [105], and the current study shows that focus group sessions can be employed to start to develop this type of shared understanding. However, it was not our goal to verify or test NPT in the current study. Future studies are necessary to explore the value of NPT in the context of aging-in-place, particularly in situations where available technological solutions need to be matched to the specific needs of each client. Furthermore, focus group sessions in the current study were mono-disciplinary, and led to findings which pointed to several differences among stakeholder groups, indicating it would be beneficial to follow up on these mono-disciplinary sessions by conducting heterogeneous sessions to further develop coherence.

Limitations

Our study is limited by the fact that it may not have included all the relevant stakeholders. For example, research shows that family members and informal caregivers can play an important role in the (effective) use of technology by community-dwelling older adults [43,106]. Additionally, the grouping of stakeholders in the current study is an oversimplification, as each stakeholder group can be broken down into more specific subgroups. Furthermore, process evaluations covering a longer period of time are needed to determine how dynamics between stakeholders influence the effective provisioning of personalized and appropriate technology that can help older adults to age-in-place. Lastly, it cannot be ruled out that our study was susceptible to selection bias since all participants were part of a project which aimed to improve the deployment of technology for aging-in-place by conducting research in the homes of older adults.

Conclusions

In conclusion, the current study adds to the limited body of work concerned with successfully implementing technology that aims to support aging-in-place. Stakeholders in the current study largely agree on the direction in which they should be heading, yet they have different perspectives with regards to the technologies that can be employed, and the work that needs to be done to implement these. Central to a successful implementation seems to be the tailoring of technology or technologies to the specific needs of each community-dwelling individual, and the work that is needed by stakeholders to support this type of service delivery on a large scale. Our findings indicate a tension between aiming to personalize technology implementations, and aiming to deploy technology en masse. It is clear that, for technology for aging-in-place to be successfully implemented, stakeholders need to engage in an ongoing mutual commitment focused on achieving the goal of empowering older adults through the use of technology.

3

Can smart home technology deliver on the promise of independent living? A critical reflection based on the perspectives of older adults

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Abstract

Expectations are high with regards to smart home technology. In particular, smart home technology is expected to support or enable independent living by older adults. This raises the question: can smart home technology contribute to independent living, according to older adults themselves? This chapter aims to answer this question by reviewing and discussing older adults' perspectives on independence, and their views on smart home technology. First, older adults' opinions on independence and aging in place are discussed. Secondly, this chapter will review to what extent smart home technology can support older adults' independence. Thirdly, it will be explained how community-dwelling older adults' concept of independence entails three distinct types or modes, and how these modes are related to their perceptions and acceptance of technology. In the last section of this chapter, an overview of key points is presented, and recommendations for technology designers, policy makers and care providers are postulated.

Introduction

The increase in longevity, the growing number of older adults and the decreasing number of newborns denote that the populations of most countries in the world are aging rapidly [17]. To date, Europe has the highest proportion of older people in the world. The increase in the proportion of older persons is primarily due to changes in health indicators including improved nutrition and hygiene [107]. Furthermore, advances in both preventive and curative medicine have resulted in an increasingly large number of (older) patients that survive medical conditions that previously used to be fatal. Unfortunately, this does not imply that older adults are all in good health and well-being. For example, the majority of older adults (i.e., over 75 years of age) report having one, two or more chronic conditions that they are suffering from [108,109]. Since age is positively related to health care utilization and, in turn, to higher health care expenditure, the influence of aging populations on society will be marked [26]. Hence, the provision of cost-effective care solutions is asked for.
To anticipate on the growing demand on health care by older adults, governments and policy makers are trying to empower older persons in maintaining independence as long as possible. By enabling them to keep residing in their own homes, i.e., to age in place, costly options such as nursing homes can be avoided. Smart homes have been postulated as a potential solution to support aging in place. A smart home can be defined as *"a residence equipped with a high-tech network, linking sensors and domestic devices, appliances, and features that can be remotely monitored, accessed or controlled, and provide services that respond to the needs of its inhabitants"* [110]. Several target groups could potentially benefit from smart home technology, one of them being older adults who would like to age in place. For example, smart homes technologies are aimed at supporting aging in place by facilitating tasks such as preparing food and cleaning. Furthermore, smart home technology can assist in monitoring and maintaining health status [111].

Despite the emphasis on smart homes by government agencies, policy makers, and the industry [112], their existence is not widespread [26,28]. Consequently, their suggested potential for older adults in promoting independence and aging in place, and thereby, alleviating pressure on (family) caregivers, and decreasing health care expenditure, has not yet reached its full potential. The question remains why smart home technologies are not yet commonplace in the homes of older people. The current chapter aims to answer this question

by reviewing and discussing older adults' perspectives on independence, and their views on smart home technology. In other words: can smart home technology deliver on the promise of independent living, according to this target group? This chapter will start by discussing older adults' opinions on aging in place and staying independent. Secondly, this chapter will discuss to what extent smart home technology can support older adults' independence. Subsequently, it will be explained how community-dwelling older adults' concept of independence entails three distinct types or modes, and how these modes are related to their perceptions and acceptance of technology. Lastly, implications and recommendations for technology designers, policy makers and care providers are postulated.

Older adults' opinions on living independently

As older age is related to decreases in health, functional abilities and social relations [113,114], the home environment is the major living space of older people [115]. A study by Gillsjo and colleagues reported the views of older adults, living in a rural community in Sweden, on their experience of 'home' [116]. This study pinpointed that home *"had become integral to living itself"* and was *"an intimate part of the older adult's being"* [116]. A study by Wiles and colleagues focused on the meaning of aging in place [117]. By conducting focus groups, the study illustrated that aging in place was perceived as an advantage in terms of security, familiarity and people's sense of identity [117]. In general, research suggests that the majority of older persons want to keep living independently, in their current dwelling [3–5].

Research also suggests that the desire to remain independent is influenced by a variety of factors including (self-perceived) health status and personal characteristics. For example, the desire to remain in one's current dwelling seems to increase with age [3]. Another study showed that, although older adults in general perceive being independent as very important, men were found to value independence as less important than women [118]. Functional status has also been suggested to influence the desire to remain independent. Being independent seems especially important to those with mild cognitive problems and/or depressive symptoms. However, older adults with severe functional limitations perceive independence as less important than older adults with no or few functional limitations [118]. Galenkamp and colleagues [118] suggest that older adults hold on to their independence up to a certain point; once their health deteriorates considerably, they seem to give up (part of) the desire to be independent in order to receive care. Similar findings are

reported in a study by Allen and Wiles [119] in which community-dwelling older adults stated that receiving informal support and using assistive technology was only considered acceptable when help was necessary due to health issues. In summary, the abovementioned findings indicate that older people wish to remain independent, but also highlight the fact that the desire to remain independent may differ per person, and that this desire is influenced by factors like health status. As a consequence, older adults' opinions on (technological) solutions aimed at supporting aging in place may also vary. In this respect, it is important to review to what extent smart home technology can support older adults' ability to live independently.

The influence of smart home technology on the ability to live independently

Many developments are taking place in the field of smart home technology, and expectations are high with regards to the potential benefits. Unfortunately, a recent published systematic review regarding smart home technology identified only three (out of 31) studies that effectively demonstrated that smart home technology can support independence and prevent health events that threaten the independence of older adults [72]. These three studies showed that the use of smart home technology was positively related to outcomes such as a reduced length of nursing home admissions [120], preservation of physical and cognitive status [121] and improved social functioning [122][1]. All three of the studies were similar in that they included a combination of technologies tailored to individual preferences of the user, including activity monitoring technology, and other functionality such as medication reminders [72]. The other 28 studies that were included in the review did not demonstrate strong evidence of support for aging in place, mainly due to their study designs and sample size (for more information, see [72]). Other systematic reviews also pinpoint that little methodically sound research is available on the effects and cost-effectiveness of smart home technology [73,123]. This raises the question: how can older adults be convinced to use smart home technology when benefits have not been demonstrated clearly in terms of scientific evidence? In this respect, it is important to consider to what extent

[1] Reeder et al. [72] classified studies as 'emerging', 'promising', 'effective (first tier)' or 'effective (second tier)'. The three studies mentioned were not considered 'effective (second tier)' by Reeder et al. [72] because they were limited by the use of a historical control group [120],high dropout rates [121], and the use of non-randomized comparison groups [122]. None of the studies included in the review by Reeder et al. [72] were classified as the highest type of evidence, which was 'effective (second tier)'.

older adults themselves perceive smart home technology as something that can help them to age in place.

A recent systematic review conducted by our research group showed that the vast majority of studies on community-dwelling older adults' perceptions on smart home technology are performed in the pre-implementation stage (when a technology has not been used yet). These studies typically include the use of presentations, vignettes or scenarios to explain or demonstrate a technology to participants [11]. Consequently, participants are asked about technology that they have not actually used and experienced for a considerable amount of time. In pre-implementation studies, community-dwelling older adults mention various concerns, when asked about their opinions on technology that is designed to support aging in place [11]. Frequently mentioned concerns are high cost and privacy implications. Additionally, a number of the mentioned concerns are related to usability; community-dwelling older adults may think that smart home technologies are hard or impractical to use. Furthermore, older adults may be concerned that they have no control over the technology, for instance its activation and de-activation. Participants in pre-implementation studies also express concerns regarding the burden it may put on their children in their role as caregivers (i.e., causing workload or worrying), and the possible negative effects on their personal health. Moreover, community-dwelling older adults express concerns that smart home technology may be too noticeable or obtrusive within their homes. Older adults can also be worried that they can be considered 'frail' or 'old' once they are seen using technology that is specifically designed for frail older adults. This fear of stigmatization can be very powerful [11,63,124–126].

While community-dwelling older adults may have concerns regarding smart home technology, they also see benefits, such as increased independence and increased safety [11]. However, these perceived benefits do not 'automatically' translate in acceptance of smart home technology. This is illustrated in a recent pre-implementation study conducted by Claes and colleagues [39], that investigated beliefs regarding contactless sensors. These sensors enable tracking of older adults' personal safety, their health status, and their ability to perform activities of daily living. According to the vast majority of the participants in this study, contactless sensors were indeed useful to age in place, both safely and independently. In sharp contrast, only a minority of respondents was willing to accept contactless monitoring at this point in their life (15.5 percent). The willingness to accept the technology later in life (82.4 percent), or in the case of health decline (91.8 percent) was remarkably higher [39]. These results are prototypical for pre-implementation studies on

technology acceptance: older adults think that smart home technology is not necessarily intended from them, but rather for other, less healthy older people [11]. This is in congruence with older adults' positive perception of their personal health, despite a decline in their objective health status [127,128].

To date, studies conducted in the post-implementation stage, when community-dwelling older adults have used and experienced a certain technology, are scarce [11]. One example of a post-implementation study was conducted by van Hoof and colleagues [129]. In this study, interviews were conducted with 18 community-dwelling older adults with a complex demand for care. The participants of this study agreed to have an unobtrusive monitoring system installed in their homes, mostly because they wanted to improve their sense of safety and security, and because they wanted to age in place. These participants reported an increased sense of safety and security in the post-implementation stage. Similar findings are reported in a post-implementation study by Pol and colleagues [130]. However, Pol and colleagues [130] note that, similar to the study by van Hoof and colleagues [129], *"participants were all old aged and experienced some age- and health-related limitations in their daily functioning"*, and that *"they were aware of their vulnerability and expressed a need for strategies to maintain independent living"*. Pol and colleagues [130] argue that these circumstances led to the acceptance of the sensor monitoring system by participants, and that research is needed to investigate whether older people who do not express or acknowledge their own vulnerability are also prone to accept smart home technology. The latter seems particularly important considering the fact that smart home technology is frequently postulated to play an important role in preventing functional decline of relatively healthy older individuals [131].

All in all, the abovementioned findings lead to a somewhat puzzling conclusion: many older adults have the desire to age in place, and many older adults also believe that smart home technology can contribute to independent living, yet these conditions often do not translate into a willingness to accept smart home technology. Only older adults who see that they may be at risk of losing their ability to live independently seem to be willing to accept smart home technology. It has been argued that a clear understanding of the motives of (potential) users of smart home technology is lacking in the current literature [28]. Therefore, the next paragraph will look more detailed at older adults' concept of independence, and its relation to perceptions and acceptance of technology.

Different types of independence, and their relations to acceptance of technology

Independence is commonly regarded as the ability to live without relying on external help, being the opposite of dependence [132]. However, in an important contribution, Sixsmith [133] showed that the concept of independence, as perceived by community-dwelling older adults, entails three specific modes or types. First, independence can imply being able to look after oneself, not being dependent on others. Second, independence can refer to self-direction; the freedom to do what you want to do. Third, independence can mean not feeling obligated to someone, e.g., family members or caregivers [133]. The first mode, being able to look after oneself, is the type of independence that policy makers aim for, and suppliers of smart home technology intent to support. Unfortunately, the other two modes of independence, although also important to older adults [133], are often ignored in the design and implementation of smart home technology. In a longitudinal qualitative field study, which our research group has been conducting since 2012, several ways in which these different modes of independence can play a role in the acceptance of technology by community-dwelling older adults have been observed [134]. In this study, 50 community-dwelling participants (with a minimum age of 70) are visited in their own dwelling, every eight months within a period of 4 years. The aim of this study is to explore and describe factors and mechanisms which influence the level of use of various types of technology (including household appliances, ICT, telephones, means of transport, and assistive technology) that are present in the homes of participants. In addition, the participants are asked to what extent they feel that technology can aid them in looking after themselves (the first mode of independence). Preliminary findings of our study indicate that, according to participants, assistive technology and means of transport (i.e., a car or an electric bike) can be important for maintaining this mode of independence. However, our findings also indicate that there is considerable amount of variation; while some participants state that assistive technology helps them to look after themselves, others indicate that they would rather do things themselves (i.e., without relying on technology): *".. we are still stubborn in a sense that we do everything ourselves"*.

Regarding the second mode of independence (the freedom to do what you want to do), older adults in our study report that certain types of technology can both support and threaten this type of independence. One example of this is the use of mobile phones. On the one hand mobile communication technology

provides participants with a sense of security, knowing that they can reach someone in case of emergency and thereby facilitating them in leaving their homes and performing activities. On the other hand, carrying a mobile phone also leaves participants open to interference by others (e.g., family members who can call participants whenever they feel they need to). This interference can lead to a feeling of 'not being able to do what you want to do'. A similar ambivalence occurs when older adults are using hearing aids. Hearing aids can have an empowering effect because they enable older adults to hear and respond to stimuli (i.e., sounds) that they would otherwise be unaware of. This enables them to engage in more activities and social interactions. However, at the same time, using a hearing aid can also lead to the avoidance of social activities such as birthday parties, due to overstimulation (i.e., hearing too much sound when many people are present). With both abovementioned types of technology, this ambivalence can lead to older adults using technology selectively: *"I only take it with me when I feel that I might be needing it"*.
Looking at the third mode of independence (not feeling obligated to someone), participants in our study frequently mention that they do not want to be a burden to others, particularly family members. For example, participants in our study mention that they want to avoid asking their children to help them in using ICT-devices, or are afraid to cause false alarms while wearing a personal alarm button. Again, these situations can cause older adults to not fully make use of certain types of technology.

The aforementioned issues are not exclusive to technology such as mobile phones or hearing aids. Studies investigating acceptance of smart home technology also point to problems that seem to be related to perceptions of independence. For instance, Boström and colleagues [38] have shown how monitoring technology can impact older adults' perceptions of Sixsmiths' [133] second mode of independence (the freedom to do what you want to do). Their research shows that community-dwelling older adults can fear that monitoring technology could 'take over' or 'take control' of their lives. Other studies have also shown that community-dwelling older adults prefer to be in control of smart home technology instead of the other way around [126,129]. Interference of technology with personal freedom may also occur in the case of lifestyle monitoring technology, which is designed to promote a healthy lifestyle by giving the user visual or auditory reminders and cues that are designed to influence the users' behavior. These reminders and cues may be perceived as meddlesome by users.
Privacy issues are another example of how acceptance of smart home technology

can be influenced by perceptions of different modes of independence. Studies have shown that technologies that enable the sharing of personal information to formal and informal caregivers can be seen by community-dwelling older persons as something that enables them to stay in their current dwelling [38,135,136]. In other words, they perceive that technology can have a favorable influence on the ability to look after oneself (Sixsmiths' first mode of independence). In addition, while some studies have shown that older adults feel that the aforementioned technologies can reduce the burden on caregivers [38,135], others have shown that older adults are worried that these technologies actually might increase the burden of caregivers [136,137]. This outlines that to older adults, smart home technology can both positively and negatively influence the feeling of being obligated to someone (Sixsmiths' third mode of independence).

The examples mentioned in this paragraph pinpoint that several of older adults' perceived favorable and unfavorable consequences of using technology in the context of aging in place can be framed in terms of how technology affects three distinct modes of independence. The findings in this paragraph also show that community-dwelling older adults can feel good and bad about a certain technology, rather than just good or bad [38].

Implications for the design and implementation of smart home technology

In this chapter we have reviewed and discussed older adults perspectives on their independence, and their views on smart home technology. The following key points were made:

- In general, older adults want to live independently in their current dwelling. However, the desire to live independently differs per person, and is influenced by factors such as health status, age and gender;
- Scientific evidence for the effectiveness of smart home technology in enabling independent living is scarce;
- Older adults who are not using smart home technology feel that it could support independent living, although they also express various concerns. They also perceive that smart home technology is not intended for themselves, but rather for another older person who is less healthy;
- The concept of independence in the eyes of community-dwelling older adults entails three specific modes or types: (1) being able to look after oneself, not being dependent on others, (2) self-direction; the freedom to

do what you want to do, and (3) not feeling obligated to someone. It is important to realize that smart home technology can affect all of these three modes of independence, often simultaneously.

The abovementioned notions have several implications for the design and implementation of smart home technology. First, technology suppliers, caregivers, and policy makers are advised to take a broad view of the concept of independence. While empowering older adults to be able to look after themselves is an important goal of smart home technology, it is also important to realize that smart home technology can, unfavorably, influence older adults' perceived personal freedom and feelings of obligation towards others. These aspects need to be taken into account in order to increase acceptance. This can be achieved by being sensitive to issues related to user-control and implications of the technology for social relationships. For instance, one must be careful not to take too much control away from older users, since this may conflict with their concept of independence. In the same way, one should be aware of the fact that social relationships between older users and their social network are influenced by technology. Of particular importance is the relation between family members and older adults, which older adults prefers to keep asymmetrical: they like to 'give' more than they 'take' [138]. Smart home technology that is not designed and implemented in line with this 'preference for asymmetry', may threaten older adult's concept of independence. The aforementioned broad view of independence could also benefit (cost-) effectiveness studies on smart home technology. Currently, effectiveness studies have a tendency to focus on measuring outcomes in line with a narrow definition of independence; the ability to look after oneself. Broadening this definition by including al modes of independence as described by Sixsmith [133], may result in a more comprehensive understanding of the effects of the use of smart home technology on the lives of community-dwelling older adults.

Secondly, the key points made in this chapter implicate that technology suppliers, caregivers, and policy makers need to be sensitive to issues regarding diversification and timing. It is important to realize that older adults' perception of independence and their use of smart home technology, may not only vary from person to person, but may also vary across time. Moreover, older adults can have different opinions on each of three modes of independence. This complicates both the design and the implementation of smart home technology. Ideally, a smart home technology would be able to adapt itself to different and/or changing independence-related needs of older adults. To our

knowledge, such a technology does not currently exist, and is very challenging to design, build, and bring to the market. One of the more difficult aspects of such 'self-adaptive technology' would be the design of algorithms to identify and monitor the user's independence-related needs. A more feasible alternative might be to let caregivers or care consultants who are in close contact with the older person, identify and monitor their needs. These identified needs should subsequently be matched with suitable smart home technologies that are available on the market. However, this would require that the particular caregiver or care consultant would have a comprehension of (psychological) aspects of aging as well as technical developments. Professionals with this skillset may be scarce and training them might be expensive. Researchers can play a role here, by developing and validating tools (e.g., interview techniques, checklists) that allow individuals to identify and monitor older adults' needs, and by developing methods that can facilitate the matching of these needs with technologies.

An underlying cause of the issues raised in this chapter may be that technology designers and older adults have different perspectives regarding the concept of independence. Other authors pinpointed that many designers typically have little understanding of the unique needs of older adults [28,46,139]. This may be caused by the fact that technology designers are usually considerably younger than older adults, which means that they may be unfamiliar with (psychological) aspects of aging, and grew up using other types of technology in comparison to older adults. To overcome this discrepancy, designers need to come into contact with older adults, preferably starting during their education. Our goal of this chapter was not to provide an extensive overview of all factors involved in the acceptance of smart home technology. Instead, we have looked at the heart of the matter: can smart home technology deliver on the promise of independent living? At this point in time, we are inclined to answering this question unfavorably. This chapter also shows that the number of studies on older adults perceptions of their independence in relation to smart home technology is limited. Additionally, a recent content analysis of industry-produced smart home marketing materials revealed *"a notable absence of user focused research"* [28,140]. In our opinion, the way forward is to deepen our understanding of the (potential) needs and preferences of older people. In this way, the promising industry of smart home technology can make an important contribution to the independence of older adults.

Part II

Factors influencing technology use
by older adults who are aging in place

4

Factors influencing acceptance of technology for aging in place: a systematic review

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Abstract

Purpose To provide an overview of factors influencing the acceptance of electronic technologies that support aging in place by community-dwelling older adults. Since technology acceptance factors fluctuate over time, a distinction was made between factors in the pre-implementation stage and factors in the post-implementation stage. **Methods** A systematic review of mixed studies. Seven major scientific databases (including MEDLINE, Scopus and CINAHL) were searched. Inclusion criteria were as follows: (1) original and peer-reviewed research, (2) qualitative, quantitative or mixed methods research, (3) research where community-dwelling older adults, aged 60 years or older, are interviewed or questioned themselves, and (4) research aimed at investigating factors that influence the intention to use or the actual use of electronic technology for aging in place. Three researchers each read the articles and extracted factors. **Results** Sixteen out of 2,841 articles were included. Most articles investigated acceptance of technology that enhances safety or provides social interaction. The majority of data was based on qualitative research investigating factors in the pre-implementation stage. Acceptance in this stage is influenced by 27 factors, divided into six themes: concerns regarding technology (e.g., high cost, privacy implications and usability factors); expected benefits of technology (e.g., increased safety and perceived usefulness); need for technology (e.g., perceived need and subjective health status); alternatives to technology (e.g., help by family or spouse), social influence (e.g., influence of family, friends and professional caregivers); and characteristics of older adults (e.g., desire to age in place). When comparing these results to qualitative results on post-implementation acceptance, our analysis showed that some factors are persistent while new factors also emerge. Quantitative results showed that a small number of variables have a significant influence in the pre-implementation stage. Fourteen out of the sixteen included articles did not use an existing technology acceptance framework or model. **Conclusions** Acceptance of technology in the pre-implementation stage is influenced by multiple factors. However, post-implementation research on technology acceptance by community-dwelling older adults is scarce and most of the factors in this review have not been tested by using quantitative methods. Further research is needed to determine if and how the factors in this review are interrelated, and how they relate to existing models of technology acceptance.

Introduction

The majority of older adults prefer to live independently for as long as they possibly can [3–6]. Supporting older adults to remain in their own homes and communities is also favored by policy makers and health providers to avoid the costly option of institutional care [141]. Research shows that several interrelated factors can challenge the independence of older adults: primarily functional and cognitive impairment, chronic diseases, a diminishing social network, and a low level of physical activity [7–10]. Technology might provide a solution for some of these challenges, and particularly in the last decade, much effort has been invested in the development of technology to support aging in place, such as sensor-based networks for activity monitoring, fall and wandering detection, and various e-health applications. However, older adults explicitly reserve the right to decide for themselves what they allow into their own homes [142], and questions have been raised on the readiness of community-dwelling older adults to accept and use these technologies [143–145]. Acceptance of technologies that are electronic or digital may be more difficult for the current generation of seniors which did not grow up with these types of technologies [146–148]. In an effort to understand older adults' usage and non-usage of modern technology, researchers often turn to two technology acceptance models, stemming from the field of information systems.

Technology acceptance models

Technology acceptance research is dominated by the Technology Acceptance Model (TAM) [47] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [48]. The key variables in TAM are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Systematic reviews have shown that these two variables typically explain 40 percent of an individual's intention to use a technology in a variety of contexts including healthcare [49–51], and that intention to use may [52] or may not [53] predict actual use of technology. UTAUT is capable of explaining up to 70 percent of intention to use at the expense of parsimony by adding two additional variables (Social Influence and Facilitating Conditions) and four moderating factors (Gender, Age, Experience and Voluntariness of Use) [48].

While being powerful and robust, TAM and UTAUT have also received criticism for disregarding the fact that technology acceptance may fluctuate over time [41,59–61]. Furthermore, several studies demonstrate that the influence of PU, PEOU, and other relevant factors is different between the pre-implementation

stage (when a technology has not been used yet) and the post-implementation stage (when users have used and experienced a technology) [149,150]. Acceptance research is also criticized for being too reliant on TAM and UTAUT, overlooking essential determinants [41,151,152]. In a recent literature review, Chen and Chan discussed 19 studies that used TAM or related models and constructs to explain technology acceptance by older adults [62]. They found that specific biophysical (e.g., cognitive and physical decline) and psychosocial (e.g., social isolation, fear of illness) factors related to aging are overlooked in the current literature.

Chen and Chan also note that the factor cost (price) of technology is neglected in many studies, although it seems to be a critical factor in determining an older adult's acceptance of technology [62]. Furthermore, most research has focused on communication- and assistive technology in the home domain, neglecting other types of technology [62]. These concerns indicate that more research is needed to develop a better understanding of acceptance of various types of technology by older adults.

Research question

This systematic review of qualitative, quantitative, and mixed methods studies examines the following research questions: which factors influence the acceptance of different types of technology for aging in place by community-dwelling older adults, and how do these factors differ between the pre-implementation stage and the post-implementation stage?

The aim of this study is to provide an overview of factors that can facilitate the implementation of technology for community-dwelling older adults, and to provide directions for further technology acceptance research within this specific group.

Technology acceptance in this study is defined as the intention to use a technology or the actual use of a technology [47]. Technology for aging in place is defined as electronic technology that is developed to support the independence of community-dwelling older adults by alleviating or preventing functional or cognitive impairment, by limiting the impact of chronic diseases, or by enabling social or physical activity. Community-dwelling older adults are defined as older adults who are not living in a long-term care institution.

Methods

Search strategy

In January 2012, seven databases (ACM Digital Library, CINAHL, IEEE Xplore, MEDLINE, PsycINFO, Scopus and Web of Science) were searched using a combination of four groups of keywords: 1) "older", "senior" and synonyms for these terms; 2) "living independently", "community-dwelling" and similar search terms; 3) search terms to find electronic technology that is aimed at supporting aging in place. Since this type of technology is studied in many different fields, it was decided to be broadly inclusive and include search terms such as "system", "e-health", "gerontechnology", "telemonitoring", "smart home", "assistive technology", and "robotics"; and 4) search terms that are related to "acceptance" and similar terms such as "use", "adoption", "adherence" and "rejection". A full list of all 150 search terms, including options and limits that were selected in the different databases, is available as supplementary material in the online version (http://dx.doi.org/10.1016/j.ijmedinf.2014.01.004)

Article selection

Titles, abstracts and full articles were subsequently screened by one author [SP] applying the inclusion criteria mentioned in Table 1. In case of doubt, three authors [SP, EW and JvH] discussed the selection. In addition, references of the included articles were checked for other articles eligible for this review (snowball method).

Table 1. Inclusion criteria

Inclusion criteria:
• Original and peer-reviewed research written in English;
• Qualitative, quantitative or mixed methods research;
• Research where community-dwelling older adults, aged 60 years or older, are interviewed or questioned themselves; and
• Research aimed at investigating factors that influence the intention to use or the actual use of electronic technology for aging in place.

Data extraction

Three authors [SP, EW and JvH] each read all included articles, and separately entered data using a data extraction form, which is available as supplementary material in the online version (http://dx.doi.org/10.1016/j.ijmedinf.2014.01.004). The first part of the extraction form includes entries on inclusion and exclusion

criteria, quality assessment, methods used, type of technology studied and implementation stage (pre-implementation/post-implementation). Articles were also checked for working definitions of acceptance and the use of existing technology acceptance models.

Articles under review used either qualitative methods, quantitative methods or a combination of both (mixed methods). In order to extract factors from all types of articles, the data extraction form contains a section for factors extracted from qualitative data and a section for factors extracted from quantitative data. In the case of qualitative articles and qualitative data from mixed methods articles, factor names and their perceived influence on acceptance were coded and subsequently entered in the qualitative section of the form. In the case of quantitative articles and quantitative data from mixed methods articles, the following information was entered in the data extraction form: variable name, standardized or unstandardized regression coefficients, level of significance, and proportion of variance explained.

Data analysis

In the first stage of the analysis, the three authors [SP, EW and JvH] had to reach consensus on every entry in the data extraction form, for each article. This was done in weekly sessions, and articles were discussed in random order. In the second stage, thematic synthesis [153] was used to synthesize qualitative data on factors. Multiple sessions were held to group factors derived from qualitative articles and qualitative data from mixed methods articles in descriptive themes for acceptance in the pre-implementation stage, and for acceptance in the post-implementation stage. Additionally, SP, EW and JvH each created a conceptual model of the relationships between themes, and subsequently one combined model was developed. In the final stage, factors derived from qualitative articles and qualitative data from mixed methods articles were compared to factors in quantitative articles and quantitative data from mixed methods articles. This was done to determine whether factors present in qualitative research are statistically tested in quantitative research and to find significant factors in quantitative research that are not present in qualitative research.

Quality assessment

Qualitative articles were screened using the Critical Appraisal Skills Program [153], which contains 10 criteria on items such as study design, recruitment

strategy, the relationship between researcher and participants, ethical considerations, data analysis and explicitness of the findings. Quantitative articles were screened using the Health Evidence Bulletins Wales checklist [154]. This checklist covers 11 criteria on cross-sectional studies including the appropriateness of sampling, the level of protection against biases and confidence in the use of statistical methods. The mixed methods articles were screened using the Mixed Methods Appraisal Tool (MMAT) [155] which, in addition to specific criteria for qualitative and quantitative research, also contains specific criteria on the relevance of the use of a mixed methods design and the integration of different types of results. It was decided not to exclude articles based on quality assessment because there is little empirical evidence on which to base exclusion decisions in mixed studies systematic reviews [155–157]. Instead, it was decided to report on the quality of the reviewed articles and to apply independent triangulation: factors had to be present in at least two studies in order to be included in the results. Furthermore, we decided that in the event of an article not meeting the minimal screening criteria of a checklist, we would examine the contribution of that article to our findings.

Results

The search in seven databases for factors influencing the acceptance of electronic technologies that support aging in place by community-dwelling older adults generated a total of 4,692 results. After the removal of duplicate results, a total of 2841 unique articles were identified (Figure 1). The selection process initially led to the inclusion of 15 articles [124,126,129,135–137,158–166]. The snowball method added one article [167], bringing the total number of articles included in this review to 16.

Characteristics of reviewed articles

The included articles were aimed at exploring factors that influence the willingness of older adults to use technology for aging in place, as well as their perceptions and expectations of this type of technology. As shown in Table 2, articles described acceptance of different types of technology, and six articles described combinations of types of technology. Technology that enhances safety (e.g., monitoring technology and personal alarms) was the most prominent type of technology, followed by technology that provides social interaction (e.g., video telephony). Technology that supports older adults in their Activities of Daily Living (ADL) or Instrumental Activities of Daily

Living (IADL) (e.g., electronic memory aids) was less prevalent. Results also show that 12 of the articles solely describe acceptance of technology in the pre-implementation stage. In these pre-implementation studies researchers typically use presentations, vignettes or scenarios to explain one or more types of technology for aging in place to the participants. In three studies, participants were allowed to interact with prototypes [126,135,159]. Evaluation of acceptance in the post-implementation stage (one article) or a combination of evaluation in the pre- and post-implementation stage (three articles) was far less common. Eleven of the 16 reviewed articles used qualitative research methods (using interviews or focus groups), four articles used a combination of qualitative and quantitative research methods (mixed methods), and one article was based on quantitative methods alone (using a cross-sectional survey). Convenience and purposive sampling was used by all articles with the exception of the article by Zimmer et al. [167], which used stratified sampling. Two articles made use of a theoretical framework to guide the search or interpretation of factors influencing acceptance: Steele et al. [126] used TAM and UTAUT [47,48], and Zimmer et al. [167] used Andersen's Model of Health Services Utilization [168]. The majority of the included research was carried out in Anglo-Saxon countries.

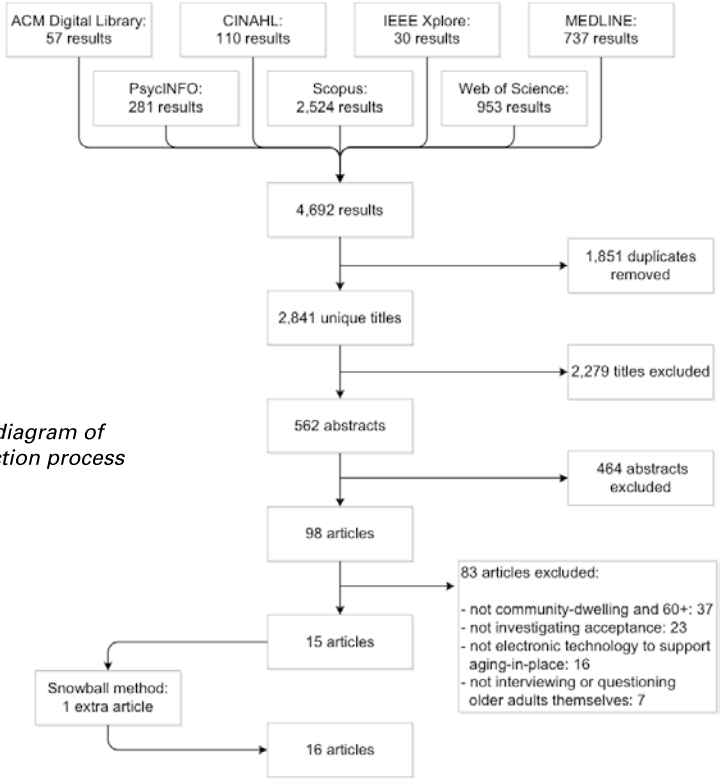

Figure 1. Flow diagram of the article selection process

Table 2. Characteristics of the 16 reviewed articles

Article	Technology type(s)			Implementation stage		Method			
First author, year [reference]	(I)ADL	Safety	Interaction	Pre	Post	Type	Instrument	N	Country
Lorenzen-Huber et al., 2011 [135]	X	X	X	X	-	Qualitative	Focus groups	65	USA
van Hoof et al., 2011 [129]	-	X	X	X	X	Qualitative	In-depth interviews	18	The Netherlands
Lai et al., 2010 [162]	-	X	-	X	-	Mixed methods	Face-to-face survey	333	China [4]
Steggell et al., 2010 [137]	X	X	X	X	-	Qualitative	Focus groups	32	USA
Steele et al., 2009 [126]	-	X	-	X	-	Qualitative	Focus groups	13	Australia
Courtney et al., 2008 [158]	-	X	-	X	-	Qualitative	Focus groups, in-depth interviews	14	USA
Demiris et al., 2008 [159]	-	X	-	X	-	Qualitative	Focus groups	14	USA
Horton, 2008 [161]	-	X	X	X	X	Qualitative	In-depth interviews	35	England
Mahmood et al., 2008 [163]	-	X	X	X	-	Qualitative	Focus group	9	USA
Mihailidis et al., 2008 [164]	X	X	X	X	-	Mixed methods [3]	In-depth interviews, face-to-face survey	15 [1]	Canada
Wild et al., 2008 [136]	-	X	-	X	-	Qualitative	Focus groups	23 [2]	USA
Cohen-Mansfield et al., 2005 [124]	X	-	-	X	-	Mixed methods	Face-to-face survey	100	USA
Porter, 2005 [165]	-	X	-	-	X	Qualitative	In-depth interviews	7	USA
Ezumi et al., 2003 [160]	-	-	X	-	X	Mixed methods [3]	Face-to-face survey	28	Japan
Porter et al., 2002 [166]	-	X	-	X	-	Qualitative	In-depth interviews	11	USA
Zimmer et al., 1999 [167]	-	X	-	X	-	Quantitative	Face-to-face survey	1406	USA

X indicates present in article
– indicates not present in article
[1] A second group of 15 older adults that did not meet our age criterion was excluded from the review
[2] A second group of 16 family members and friends was excluded from the review.
[3] Statistical methods were not used on quantitative data in this article.
[4] Research was conducted in the Hong Kong special administrative region.

Quality of reviewed articles

Looking at the quality of the qualitative articles, the majority of the articles met most of the criteria. There was one criterion that was only met by one article [135]. In this criterion it was assessed whether researchers critically examined their own role, potential bias and influence in the process of conducting the study. A criterion on the consideration of ethical issues was met by half of the included articles.

The one quantitative article [167] met all the criteria except for a criterion on the consideration of alternative explanations for effects, and a criterion on the validation of survey questions.

Looking at the mixed methods articles, the quality of one article [160] could not be assessed completely because we considered the research question of this article ambiguous and it therefore did not meet the screening criteria of the MMAT [155]. The other mixed methods articles met the majority of the criteria, but none of the articles met the criteria on consideration towards the influence by the researcher, the validity of quantitative measurements and consideration of the limitations associated with integration of qualitative and quantitative data.

Qualitative results on pre-implementation acceptance

Qualitative results show that acceptance of technology for aging in place in the pre-implementation stage is influenced by 27 factors, divided into six themes (Table 3). The largest theme contains concerns that have a negative influence on the pre-implementation acceptance of technology for aging in place (Figure 2).

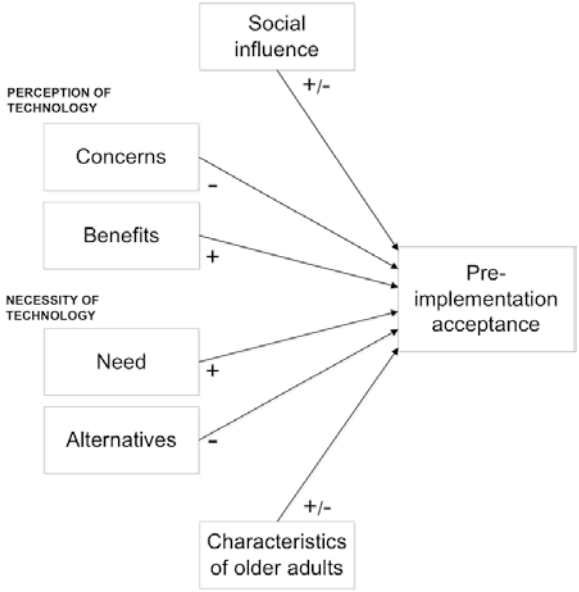

Figure 2.
Model of pre-implementation acceptance

Table 3. Pre-implementation acceptance factors

Theme	Factor	Number of articles	References
Concerns regarding technology	High cost	7	[124,126,137,161,162,164,166]
	Privacy implications	7	[126,135–137,158,159,164]
	Forgetting or losing technology	4	[124,126,136,137]
	False alarms	3	[158,161,164]
	Obtrusiveness	3	[126,136,159]
	Burdening children	2	[135,137]
	Ineffectiveness	2	[162,166]
	Impracticality	2	[124,164]
	Low ease of use	2	[124,126]
	Negative effect on health	2	[126,137]
	No control over technology	2	[126,164]
	Stigmatization	2	[124,126]
Benefits expected of technology	Increased safety	6	[135–137,159,162,163]
	Perceived usefulness	3	[126,135,164]
	Increased independence	2	[129,137]
	Reduced burden on family caregivers	2	[135,136]
Need for technology	Perceived need	9	[126,135–137,158,161,164,166]
	Subjective health status	2	[158,159]
Alternatives to technology	Help by family or spouse	5	[126,159,162,164,166]
	Current technology	2	[136,158]
Social influence	Influence of family and friends	3	[135,158,166]
	Influence of professional caregivers	2	[135,158]
	Use by peers	2	[159,166]
Characteristics of older adults	Desire to age in place	6	[126,129,135,136,163,164]
	Cultural background	2	[137,162]
	Familiarity with electronic technology	2	[126,164]
	Housing type	2	[126,158]

Concerns regarding technology

Community-dwelling older adults express various concerns when they consider technology for aging in place that they have not yet used. One of their major concerns is high cost, which is mentioned in half of the articles. When it is described, it has a prominent role: *"Costliness was identified as the major concern most often"* (p. 15) [124] and *"Cost was the most significant concern to the elderly participants ... and is the most likely topic for participants to refer back to regardless of what issue was being discussed."* (p. 793) [169]. Privacy implications are another concern mentioned in half of the articles, although participants from different studies mention that they would be willing to give up (some) privacy as long as the use of technology would be beneficial to them; for instance: *"You'd have to come to an agreement. You give up some of your privacy and give up some of these things in order to stay where you are."* (p. 242) [135]. A number of concerns are related to usability; community-dwelling older adults mention that they fear that technology may be hard or impractical to use. Some participants are also concerned that they have no control over the activation and de-activation of the technology: *"You've got to be able to have control of it. I think you should have a screen somewhere, that maybe you can check if you think you may have set it off, well you can go see if you have or not..."* (p. 795) [126]. In addition, participants regularly express concerns regarding the consequences of using technology, such as the burden it might put on their children in their role as family caregivers, or the negative effects on their personal health: *"Could the sensor radio waves give you cancer? I think this is what I would be worried about."* (p. 793) [126]. Others are concerned that the use of technology might fail to achieve its goal and may prove to be ineffective. Regarding the appearance of technology, community-dwelling older adults express concerns that the technology might be too noticeable or obtrusive within their homes.

In a related concern, participants are worried that other people may perceive them to be in poor health or frail, once they are seen wearing technology that is specific to frail older adults. This fear of stigmatization can be very powerful, and one participant described wearing a personal alarm button as like wearing a *"badge of dishonor"* (p. 31) [165]. When older adults think about using personal alarm buttons or portable health monitoring sensors, they are concerned that they might forget to use them or lose them. In the case of health or safety monitoring technology, participants are concerned about false alarms: *"... if you're in the shower and you bend over to pick up your soap and it thought you'd fallen– there could be false alarms... and I don't want it sending for the ambulance if I've only bumped my knee."* (p. 793) [169].

Benefits expected of technology

Although community-dwelling older adults express technology related concerns, they also expect the use of technology for aging in place to be beneficial. These expected benefits have a positive influence on their pre-implementation acceptance. Older adults mention that they would use technology when they perceive it as useful, although often it is not made clear what constitutes this perceived usefulness: *"If the thing is good, and it works, then we go for it. However, if we see something that is useless, and obtrusive, and is change for change's sake, then no. Not interested."* (p. 796) [169]. In other cases, the benefits are more concrete, and the most frequently mentioned benefit is an expected increase in safety: *"It will increase the life time because if you get into an accident… you will be discovered sooner and can get to emergency room before it is too late…"* (p. 442) [137]. Additionally, participants mention that they expect that the use of technology for aging in place will increase their independence or reduce the burden on family caregivers.

Need for technology

Whether or not community-dwelling older adults are willing to use technology also depends on their perceived personal need for technology. Perceived need is the most frequently mentioned factor overall, and when it is present the acceptance of technology is more likely. However, in most articles participants state that technology for aging in place is needed for a hypothetical other older person, rather than for themselves: *"I don't need this now, but perhaps at a later point—I have friends who'd benefit from this a great deal, I am not there yet…"* (p. 122) [159]. In some instances, an older adult's negative subjective health status positively influences his or her perceived need and acceptance of technology; for example, in the case of a participant who recently fell: *"If you had told me two months ago [about these technologies] I'd say who needs it, but after what I have been through, I see the benefits."* (p. 122) [159]. In other cases, however, a negative health status does not increase the perceived need for technology: *"One woman who had balance issues and a history of falls described her health condition and then stated that she did not need fall detection technology at this time."* (p. 199) [158].

Alternatives to technology

Available alternatives to technology for aging in place can negatively influence its acceptance. For instance, help by family members or a spouse can reduce

the need for technology-based monitoring [158]. Additionally, certain types of technology that are currently used can make other types of technology seem redundant in the perception of participants. An example of this is the reduced need for a fall-detection system when a personal alarm button is available [158].

Social influence

Community-dwelling older adults are also influenced by key figures within their social environment when deciding whether or not to use technology for aging in place. An example of this is the influence of their children: *"Several noted the importance of their children's concerns when determining if they needed a service or a technology."* (p. 199) [158]. In some cases, the children's influence can be compelling: *"I am very compliant about these kinds of things. I am not compliant with the thoughts of my mind, but I am compliant about following directions [from my adult children]."* (p. 241) [135].
Besides children, professional caregivers and friends and family can also positively or negatively influence acceptance. Furthermore, community-dwelling older adults are influenced by the acceptance of technology by their peers: *"Everybody I've talked to that's tried it out, they don't care for it… My general feeling is that people don't care for them. [Are you thinking about getting it now?] Not at this point."* (p. 195) [166].

Characteristics of older adults

Several characteristics of community-dwelling older adults can positively or negatively influence acceptance of aging-in-place technology. One of the more prominent factors is the desire to age in place: *"All the respondents in this study want to stay in their current dwelling because of attachment to the own home, memories of the past, and their possessions in the home, as well as the quality of the neighborhood."* (p. 318) [129], and *"I would choose home, I think most people would … Nobody chooses to go to a nursing home."* (p. 792) [126]. The desire to age in place sometimes leads to acceptance of technology for aging in place, but not in all cases. Other factors are the familiarity of the older adult with modern electronic technology, and the fit between housing type and certain types of technology. Lastly, is the issue of whether or not the technology is compatible with the older adult's cultural background: *"A uniquely Korean value emerged in the discussion of the sleep monitor. Dying while sleeping is considered very lucky in the Korean tradition. Participants were concerned that technology might interfere with their luck."* (p. 442) [137].

Comparison with qualitative results on post-implementation acceptance

Analysis of qualitative results on post-implementation acceptance shows that some pre-implementation factors are also present in the post-implementation stage. For example, when older adults have used and experienced technology, they are still concerned about privacy implications [129,161] and stigmatization [160,165]. Furthermore, many participants are still not sure if they themselves actually need technology for aging in place, and the perceived personal need of these community-dwelling older adults [129,161] continues to play a role in their technology acceptance. Lastly, the expected benefit of increased safety [129,165] continues to positively influence acceptance.

At the same time, new factors emerge in the post-implementation stage. Some of the older adult's pre-implementation concerns turn into real life problems; for example the occurrence of false alarms [129,165]: *"I've not been very successful with it. I don't think it really worked for me; it kept giving these false alarms and they became quite a nuisance that I'd never bothered to wear it after a while."* (p. 1188) [161]. This also happens with the concern of forgetting or losing personal alarm buttons or other types of portable technology [129,161,165]: *"… I was good for the first few months, then I went away for a few days, and I couldn't have it with me because it wouldn't work in my daughter's house. Then I came home and I suppose it's like most things, you try it for a while and then you forget it."* (p. 1189) [161]. Besides concerns becoming reality, there is also the problem of technology not working in certain locations [160,165], thereby lowering its acceptance. An example of this is portable technology that does not work in the shower. Another inhibitor of technology acceptance that was not mentioned in the pre-implementation stage, is the availability of home care as an alternative to technology for aging in place [129,165]. Lastly, the level of satisfaction with the new technology [160,161] and the affect towards the new technology as a result of using it [129,165] influence technology acceptance in the post-implementation stage.

Comparison with quantitative results on pre-implementation acceptance

Analysis of quanitative results shows that several variables that are similar to qualitative factors have been statistically tested on pre-implementation data, using regression analysis. At the same time, a small number of variables not present in the reviewed qualitative pre-implementation research were also tested. In this section, significant results are presented (Table 4).

In the study by Cohen-Mansfield et al. [124], the number of concerns regarding using a device (including high cost, low ease of use, impracticality, and

stigmatization) has a significant negative influence on the acceptance of electronic memory aids. Furthermore, the importance attributed to functions of the device, which resembles the qualitative factor of perceived usefulness, positively influences acceptance. Cohen-Mansfield et al. [124] also found that acceptance of electronic memory aids is positively influenced by the number of different prescriptions taken; a variable that is not present in the reviewed qualitative research.

Lai et al. [162] studied community-dwelling older adults' acceptance of a vital signs monitoring system and their acceptance of a motion monitoring system. They found that the number of self-reported chronic illnesses, which bears resemblance to the qualitative factor of subjective health status, positively influences acceptance of a vital signs monitoring system. At the same time, this variable has no significant influence on the acceptance of a motion monitoring system. This also applies to age, which was found to negatively influence the acceptance of a vital signs monitoring system, but not the acceptance of a motion monitoring system. In addition to age, two other variables that are not present in the reviewed qualitative research were studied: gender and level of education. Both negatively influence the acceptance of a motion monitoring system, but not the acceptance of a vital signs monitoring system. Lai et al. did not specify whether the motion monitoring system was more accepted by males or females.

Lastly, in the study by Zimmer and Chappell [167], the acceptance of electronic safety devices is positively influenced by two variables that are similar to the qualitative factor of subjective health status: the number of self-reported health symptoms and the number of self-reported dexterity problems. The number of safety and security concerns (which corresponds to perceived need) also positively influences acceptance. Finally, three variables that are not present in the reviewed qualitative research also influence acceptance of electronic safety devices: age (negative influence), level of education (positive influence), and rural residency (positive influence).

Table 4. Significant pre-implementation variables and similar qualitative pre-implementation factors

Significant quantitative variables				Similar qualitative factors	
Ref.	Variable	Technology studied	Significance level	Theme	Factor
[124] [1]	Number of concerns regarding using a device (including high cost, low ease of use, impracticality, and stigmatization)	Electronic memory aids	p<.05, Beta =-. 17, R^2 =.30	Concerns regarding technology	High cost, low ease of use, impracticality, and stigmatization
	Importance attributed to functions of the device	Electronic memory aids	p<.05, Beta = .44, R^2 =.30	Benefits expected of technology	Perceived usefulness
	Number of different prescriptions taken	Electronic memory aids	p<.05, Beta =.25, R^2 =.30	-	-
[162] [2]	Number of self-reported chronic illnesses	Vital signs monitoring system	p<.001, B =1.718, R^2 =.22	Need for technology	Subjective health status
		Motion monitoring system	Not significant		
	Age	Vital signs monitoring system	p<.001, B =-1.284, R^2 =.22	-	-
		Motion monitoring system	Not significant		
	Gender	Vital signs monitoring system	Not significant	-	-
		Motion monitoring system	p<.05, B =-0.785, R^2 =.13		
	Level of education	Motion monitoring system	p<.05, B =-0.911, R^2 =.13	-	-
[167]	Number of self-reported health symptoms	Electronic safety devices	p<.05, Beta = .06, R^2 =.15	Need for technology	Subjective health status
	Number of self-reported dexterity problems	Electronic safety devices	p<.05, Beta = .06, R^2 =.15	Need for technology	Subjective health status
	Number of safety and security concerns	Electronic safety devices	p<.01, Beta = .27, R^2=.15	Need for technology	Perceived need
	Age	Electronic safety devices	p<.01, Beta =- .08, R^2 =.15	-	-
	Level of education	Electronic safety devices	p<.05, Beta = .06, R^2 =.15	-	-
	Rural residency	Electronic safety devices	p<.01, Beta = -.09, R^2 =.15	-	-

– indicates not described in qualitative articles [1] Significance levels for this study were confirmed by contacting the corresponding author because these were not reported in the original article. [2] Data on a Personal Emergency Link Service (PELS) was excluded because only subscription status was analyzed, and not actual use or intention to use.

Discussion

Main findings

This is the first systematic review to identify factors that influence acceptance of electronic technology for aging in place. Since technology acceptance factors fluctuate over time, a distinction was made between factors in the pre-implementation stage and factors in the post-implementation stage. Sixteen articles based on qualitative, quantitative or mixed methods were identified. Most articles investigated acceptance of technology that enhances safety or provides social interaction. The majority of the data was based on qualitative research investigating factors at the pre-implementation stage. Results show that acceptance of technology at this stage is influenced by 27 factors, divided into six themes: concerns regarding technology (e.g., high cost, privacy implications and usability factors), expected benefits of technology (e.g., increased safety and perceived usefulness), need for technology (e.g., perceived need and subjective health status), alternatives to technology (e.g., help by family or spouse), social influence (e.g., influence of family, friends and professional caregivers) and characteristics of older adults (e.g., desire to age in place). When comparing these results to qualitative results on post-implementation acceptance, analysis shows that some pre-implementation concerns, such as the fear of forgetting or losing technology, turn into real life problems in the post-implementation stage. Furthermore, factors such as perceived need and stigmatization are persistent. New factors also emerge, for example satisfaction with technology and affect towards technology. Quantitative results show that a small number of variables, such as subjective health status, that are similar to qualitative factors, have a significant influence in the pre-implementation stage. Results for background variables, such as age and level of education, are mixed. Fourteen articles did not use an existing technology acceptance framework or model.

Strengths and limitations

This review's strengths lies in its extensive search strategy, covering databases in the fields of social sciences, health care and technology. This systematic and multidisciplinary approach is also reflected in the extraction of factors from qualitative research, which was done by three independent reviewers from different backgrounds (psychology, medicine and engineering). Another strength is the inclusion of all types of available evidence, regardless of the type of research method (qualitative, quantitative or mixed methods).

One mixed methods article [160] did not meet the screening criteria of the checklist that was used [155], due to an ambiguous research question. However it did contain data that helped us answer our research question. When we look at the contribution of this article to our data, it shows that three post-implementation factors were extracted from this article. Each of these factors were also mentioned by one other article. This indicates that the contribution of this study to the findings was supportive rather than decisive. This is in accordance with findings by Thomas and Harden, who showed that the contribution of studies that were assessed as having a lower quality was modest compared to studies that were assessed as having a high quality [156]. This review provides an overview of factors, but it does not differentiate between types of technology. Furthermore, moderating or mediating relationships between factors have not been investigated due to a lack of available data. This also implies that these types of relationships are not covered in the presented model of pre-implementation acceptance.

Relation to other studies, reviews and models

The majority of the included articles lack a theoretical approach, which hampers interpretation and comparison of findings between studies in this field. A similar problem has been reported by authors reviewing technology acceptance of consumer health information systems [170] and telemedicine [171]. When relating the results of this review to TAM and UTAUT, it appears that acceptance of technology for aging in place by community-dwelling older adults in the pre-implementation stage is influenced by more factors than just the key constructs of the TAM and the UTAUT. One example of this is the fact that community-dwelling older adults mention more benefits of technology for aging in place than just Perceived Usefulness[2]. However, it is possible that the other benefits that community-dwelling older adults mention, such as increased safety and increased independence, are in fact antecedents to Perceived Usefulness. An alternative explanation is provided by the authors of the value-based adoption model (VAM) [172], who state that TAM is very useful in organizational contexts, but not in the context of consumers who have to make their own personal evaluation of the costs and benefits of using a technology. Therefore, in the VAM multiple Perceived Benefits and multiple types of Perceived Sacrifices together determine the Perceived Value of a technology to the consumer, which in turn influences an individual's intention

[2] Davis [47] and Venkatesh [48] define Perceived Usefulness or Performance Expectancy as "The degree to which an individual believes that using the system will help him or her to attain gains in job performance."

to use a technology. Perceived sacrifices can be monetary or non-monetary. Examples of non-monetary costs are time costs, effort costs and psychological costs. In VAM, TAM's Perceived Ease of Use construct is considered to be a Perceived Sacrifice [172]. The theme "concerns" in this review resembles the construct of Perceived Sacrifices. Up until now VAM has been used successfully in explaining consumers acceptance of mobile internet [172] and Internet Protocol TeleVision [173]. At the same time Venkatesh, Thong and Wu have proposed and tested UTAUT2 , which is also aimed at explaining consumer behavior, and contains the construct of Price Value which is defined as *"a cognitive tradeoff between the perceived benefits of the applications and the monetary cost"* [57]. The study by Cohen-Mansfield et al. [124] that is included in this review provides some statistical support for the role of cost-benefit evaluations, but to our knowledge VAM and UTAUT2 have not been tested in the context of older users.

This review also shows that other mechanisms besides cognitive cost-benefits tradeoffs come into play when older adults are considering the use of technology. Whether or not older adults feel the need for technology to support their aging in place is important in their acceptance of technology, both in the pre-implementation and post-implementation stage. Perceived Need plays a similar role in Andersen's Model of Health Services Utilization [168], where it is the most immediate predictor of health service use. The articles in this review indicate that many community-dwelling older adults do not feel the need for supportive technology. This is in accordance with some of the strategies for coping with decline that community-dwelling older adults employ, such as "trying to keep one's' mind from focusing on oneself and one's own vulnerability" [174] and "focusing on the present" [175]. More research is needed to understand how older adults' coping strategies are related to the use of supportive technology, especially since this review also shows the ambiguous relationship between older adults' desire to age in place and the use of technology designed to support that same goal. Perceived Need has also proven to be an influential factor in research on the acceptance of non-electronic assistive devices according to a systematic review by Steel and Gray [169]. Other factors in this review are also similar to factors in our review, such as fear of stigmatization, effectiveness, and cost. Additionally, Steel and Gray stress that acceptance of technology can be improved by training users and making sure that technology matches an individual's level of functioning, goals, preferences and needs [169]. These types of implementation factors have possibly not received much attention in the reviewed literature because

the majority of the included studies was performed at the pre-implementation stage.

It is clear that pre-implementation acceptance of technology also depends on social factors since family, friends, professional caregivers and peers are all described as having an influence. Social influence also play an important role in several of the theories that are mentioned in this paragraph [48,57,168,176]. Some of the alternatives that prevent older adults from using technology for aging in place, such as help by a spouse or help by a family member, are also social factors. Additionally, alternative technology that is already accepted can prevent the use of new technology. This review also points to other pre-existing conditions that can influence acceptance, such as familiarity with electronic technology and cultural background. These pre-existing conditions are also described in Triandis' Theory of Interpersonal Behavior [176]. Research by Wilson and Lankton [177], that is based on Triandis' theory, shows that pre-existing conditions such as age and presence of chronic health conditions have a direct effect on e-health use by patients. This is partly confirmed by studies in this review that found significant effects for the effects of age and number of chronic illness on the acceptance of a vital signs monitoring system [162] and electronic safety devices [167], but not on the acceptance of a motion monitoring system [162].

Implications for practice and research

Professional caregivers, product developers, managers, policymakers, and family members who are interested in stimulating community-dwelling older adults to start using technology for aging in place, need to be aware that acceptance depends on a large number of factors that may vary for each individual. Most of the time, an older adult will have a number of specific technology-related concerns, while the perceived benefits of a technology might be more abstract. Therefore, it is necessary to communicate concrete benefits to the older adult and, at the same time, reduce technology-related concerns specific for that individual. Demonstration of the technology, the opportunity to try out the technology in a risk-free environment, and training or coaching can be used for this purpose. It is advisable to involve professional caregivers, family members, and peers who already use the new technology in these interventions, since older people are sensitive to their influence. When an older adult does not see the need for a technology, it is highly unlikely that he or she will be inclined to start using it. However, at this time it is uncertain if

perceived need can be influenced, and if it is desirable to do so. It is, therefore, recommended to keep track of an older adult's perceived need for technology in order to coordinate the introduction of technology accordingly. It is also advisable to be sensitive to the fact that community-dwelling older adults do not exclusively look at technology as a means to enable aging in place; they also consider alternatives such as help by others or the use of their current technology. In fact, available alternatives might prevent them from using new types of technology.

Meanwhile, several gaps regarding research on the acceptance of electronic technology for aging in place by community dwelling older adults can be identified. First, while data on factors influencing acceptance in the pre-implementation stage are comprehensive, results regarding acceptance in the post-implementation stage are limited by the small number of studies. In order to support the independence of community-dwelling older adults for long periods of time, more research is needed to understand what drives continued or sustained use of technology once it has been implemented. This requires longitudinal research investigating the influence of factors in multiple stages of use, such as those proposed by Rogers [178] or Chui and Eysenbach [179]. Secondly, there is a dearth of quantitative research in the pre-implementation stage and quantitative research in the post-implementation stage is nonexistent. More quantitative research is needed to understand which factors are more influential than others and to investigate moderating or mediating relationships between factors.
Thirdly, research until now has primarily focused on technology that provides safety through monitoring, and to a lesser extent on technology that supports (I)ADL or social interaction. More research is needed on the acceptance of other types of electronic technology for aging in place, such as technology for chronic disease management or technology that stimulates physical activity. This is also necessary in order to gain a better understanding of which core factors are influential in explaining the acceptance of multiple types of technology, such as perceived need, and which factors are more technology specific. Lastly, authors investigating technology acceptance by community-dwelling older adults are encouraged to make use of existing theories on the use of technology and to develop theories suitable to the context of community-dwelling older adults. In conclusion, more research is needed to capture the complexity and timeline of the acceptance process of different types of electronic technology for aging in place by community-dwelling older adults.

5

Older adults' reasons for using technology while aging in place

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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 level 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 semi-structured 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.

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 percent in 2012 to 26 percent in 2040 [180]. 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 [71,141]. Additionally, technology is frequently postulated as a means of supporting aging-in-place [72,181]. For example, in the Netherlands, technological innovations are expected to enable an increase in the number of dwellings that are suitable for older people [182]. Various types of technology are specifically designed to support aging-in-place, such as emergency help systems, vital signs monitoring, and fall detection systems [11]. These technologies are sometimes referred to as Smart Home technology [66]. Additionally, there is e-Health, which encompasses a broad range of technologies, including online tools to support older adults' self-management of chronic conditions [183]. These technologies, however, have not been implemented on a large scale due to various reasons [11,26,66,182]. 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 [11,63]. Additionally, there are generally available consumer Information and communication technologies (ICTs), which are also expected to provide benefits to older adults who would like to remain independent. Examples include the use of social network sites (SNS) 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 percent of the individuals aged 65 to 74 make use of the Internet, and of this group 33 percent use SNS. At the same time, only 30 percent of the individuals aged 75 or older use the Internet, and of this group 18 percent uses SNS [64]. This phenomenon is sometimes referred to as 'the digital divide' [184].

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 [185,186].

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 [186,187]. 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) [47], and the Unified Theory of Acceptance and Use of Technology (UTAUT) [48]. Both models originally were aimed at explaining technology (non-)use by individuals in organizations. The predictor variables in TAM are perceived usefulness and perceived ease of use, while UTAUT 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 TAM and UTAUT 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) [11,62,63]. 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 [63]. 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 [33]. 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, Bouma and Fozard [83]. 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 [188].

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 [7], as well as lower usage levels of several types of technology (e.g., ICTs and mobile phones) [48,62,64]. 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 percent). Health issues and lack of interest were reasons for non-participation. 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 one-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 to 150 minutes, 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 hers level of technology use were gathered. This was done to provide the researchers with background information relevant for the semi-structured 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) [189], and cognitive functioning as measured by the Mini Mental State Examination (MMSE) [190]. 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 on 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 semi-structured, 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 [11]. 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 (SP or MR), and a second researcher with a background in healthcare or engineering (MN, CvdV

or JvH). 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, one participant responded that she was misinterpreted on one occasion during her interview, which was taken into account while analyzing that particular interview. The Ethical Review Board for the Tilburg School of Social and Behavioral Sciences approved the study. During the home visits, three participants stated that they were younger than 70 years. Because of ethical considerations, these participants were not excluded.

Analysis

Thematic analysis [82] 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 [11] were used as sensitizing concepts [191]. Each transcript was coded independently by two 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 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 eight weeks, and in the last two 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 percent of the participants were female. Just over 71 percent of the participants lived alone, and 64

percent received home care. Of the participants, 32 percent had attained no or only primary education. Nearly 55 percent had attained some form of secondary education, while 13 percent attained higher education. The majority of the participants (71 percent) considered their health to be (very) good, or excellent. Additionally, nearly 65 percent of the participants had three or more self-reported chronic conditions. Just over 52 percent 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 regards 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 percent 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.

Table 1. Sample Characteristics (N=53)

Age: mean (SD)	**78.0 (6.0)**
Age: n (%)	
65 – 69	3 (5.7)
70 – 74	11 (20.8)
75 – 79	21 (39.6)
80 – 84	11 (20.8)
85 – 89	5 (9.4)
90+	2 (3.8)
Gender: n (%)	
Female	34 (64.2)
Male	19 (35.8)
Living arrangement: n (%)	
Alone	38 (71.7)
With a partner	15 (28.3)
Receiving home care: n (%)	
Yes	34 (64.2)
No	19 (35.8)
Educational attainment: n (%)	
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: n (%)	
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: n (%)	
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 [1]: n (%)	
24 – 26	11 (20.8)
27 – 30	42 (79.2)

[1] As suggested by Kempen, Brilman and Ormel [229], a score of 24 was used as the cut-off point for cognitive impairment.

Table 2. Number of Devices per Participant, and Average Frequency of Use in the Last Two Months, by Type of Device (N=53)

		Number of devices per participant		**Average frequency of use in the last two months**				
Type of device	Examples	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

Emergent themes and subthemes

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, and the role of the physical

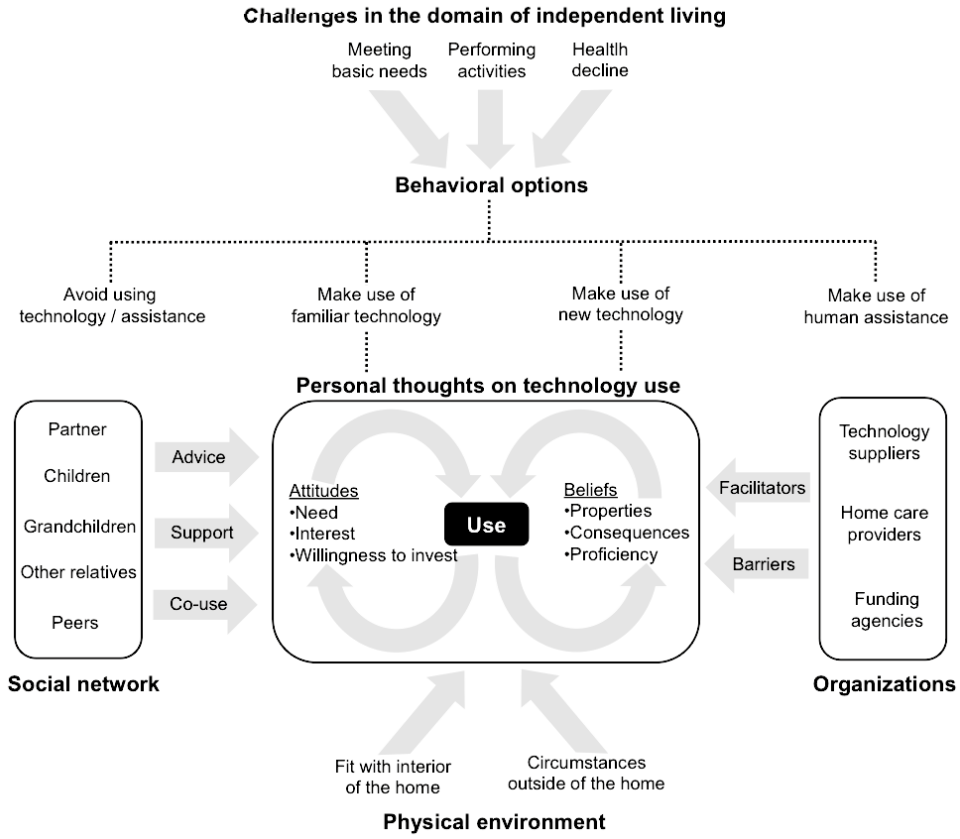

Figure 1. Conceptual model of factors influencing the level of technology use by older adults who are aging in place. Major themes are in bold type, subthemes are in normal type.

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 to meet, 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. Secondly, 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, one 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 technology 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 'non-technological' 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 in 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 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 to 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.
Secondly, 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 emailed, 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, 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). Secondly, 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 qualitative themes and 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 [47,48]. However, the role of alternatives is recognized in models of health care utilization [168] and

consumer behavior [192,193]. The current study indicates that alternatives are also relevant in explaining and understanding technology use. With regards 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 [11,63,111,186,194,195]. Recently, qualitative studies were performed in Hong Kong [194] and in England [195]. 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 [38,111]. 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 [7,8].

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 [186,196], 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 [194,195], as well as research pointing to the importance of relatives to older people, and the complex nature of family ties [138]. 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*" [178]. This is largely overlooked by classical technology acceptance models [47,48], who have reduced social influences to the construct of 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 influenced 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 [63] 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 they are wary of technology that they consider too obtrusive within their homes [197,198]. These findings also support appeals from the fields of health geography [199,200] and environmental gerontology [201], 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 regards 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 regards 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 non-users 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 three 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 to other qualitative studies [202], and our results are in many ways similar to studies in different contexts [194,195], 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"* [203]. In light of these developments, the role of technology is becoming increasingly important, not only because it could provide older individuals 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. Policymakers, 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 [204], 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 stimulating

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.

6

"Grandma, you should do it—it's cool" Older adults and the role of family members in their acceptance of technology

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Abstract

Despite its potential, the acceptance of technology to support the ability to live independently in one's own home, also called aging in place, is not optimal. Family members may play a key role in technology acceptance by older adults; however, it is not well understood why and how they exert influence. Based on open interviews with 53 community-dwelling older adults, this paper describes the influence of family members, including spouses, on the use of various types of consumer electronics by older adults as was reported by themselves. Such a broad focus enables understanding the use of technology as was reported by older adults, instead of its intended use. Our study reveals that the influence of each family member has its own characteristics. The influence of technology acceptance is a natural and coincidental part of the interaction with spouses and grandchildren in which entertainment and pleasure are prominent. This is also partly true for the influence of children, but their influence also is intentional and driven by concerns. Our study indicates the importance of including all family members when implementing technology in the lives of older adults. Besides information for children about the use(fullness) of devices, it is worthwhile to give grandchildren an important role, because older adults easily adopt their enthusiasm and it might eventually lighten the burden on children.

Introduction

In general, older adults wish to live independently in their own homes as long as possible, also known as aging in place. In both Eastern and Western countries, older adults cherish their independence because it provides them with the opportunity to live their lives as they always have and to make decisions as has been customary for them [205–209]. Governments encourage independent living by older adults because of demographic changes and economic crises. This policy also fits changing perceptions of the position of citizens in need of care and fits the necessity and value to arrange care near older adults, as is the case in the Netherlands [210]. Ensuring sufficient care of adequate quality for community-dwelling older adults will therefore be one of the challenges for the coming years. Technology has the potential to provide a solution for at least part of the care needs of community-dwelling older adults [211,212]. Although various specific electronic devices to support aging in place have been developed (e.g., fall detection systems and monitoring technology), the acceptance of these types of technology, in the sense of (intended) use, as was reported by older adults themselves [47], could probably be greater [66,144,145].

The absence of insight into the experiences, attitudes, and opinions of older adults who use technology to support aging in place might partly explain why such technology is not accepted more often [135,195]. There may be many unintended consequences to using technologies that have not yet been discovered. Older people may be wise in not adopting new technologies. All technology use (and change in general) comes at a cost. Ultimately, individuals make their own decisions about appropriate technology use to suit their needs. In making those decisions, it is plausible that members of the social network influence the acceptance of technology by older adults [43]; currently, it is not well understood why and how they exert this influence. A systematic literature review reveals that, until now, knowledge of the perspective of older adults on technology to support aging in place has been mostly limited to older adults' intention to use technology sometime in the future, called the pre-implementation stage. Sixteen articles were included, of which twelve focused solely on intention to use technology, three evaluated both intention to use and use, and only one article evaluated use exclusively [11]. Understanding factors that influence the use of technology by older adults in their own homes is important to facilitate the acceptance of technology that could support independent living. Moreover, it is important to study the

perspective of older adults themselves, as was done in this paper, because studies reveal that older adults and professional caregivers, including doctors, differ in their perception of what is important to older adults [213–216]. As was also established by social cognitive theory [217], social relations in general are important to older adults [195,207,208,218–220], and previous research indicates that the role of the social network is essential in enabling older adults to use assistive technology as well as household appliances and computers [11,43,194,195,221–223]. The influence of children, other family members, friends, and professional caregivers can be both favorable and unfavorable in terms of technology acceptance [11]. For example, female family members often help in selecting and buying technology, while male family members often help with adapting technology to fit the needs of the older adult [195]. On the other hand, older adults and family members do not always agree on the need for technology [43]. Additionally, older adults want to avoid asking too much of other people, especially of their children. In their deliberations of how to keep their autonomy and independence, negative and positive consequences for their children weigh heavily. For example, although most people want to avoid moving to a care facility or nursing home, they are willing to seriously consider it when they think it would be beneficial for their children [135,207,224]. Although members of the social network influence the acceptance of technology by older adults [11,43,194,195,221–223]; currently, it is not well understood why and how they exert this influence.

Not all members of the social network seem to be equally important: in comparison with other members of the social network (e.g., friends, peers), family members seem to be the most important when it comes to how older adults live their lives and what solutions they choose when their autonomy is at stake [135,207,224]. Furthermore, it is known that spouses influence each other's health behavior [225–227] and could also be of influence to each other's acceptance of technology. Therefore, the following research question is central in this paper: Why and how do family members, including spouses, influence the acceptance of technology by community-dwelling older adults, according to older adults themselves?

In this study, we did not narrow our focus to technology specifically designed to support aging in place but studied various types of consumer electronics. Such a broad focus enables data gathering about technology that is in the home and is used. Studying consumer electronics reveals actual experiences, attitudes, and opinions of community-dwelling older adults instead of expectations in the future. We believe that understanding social factors that

influence the acceptance of regular consumer electronics will be helpful in understanding social factors that influence the acceptance of technologies that are specifically designed to assist aging in place. Moreover, many of the regular consumer electronics also have the potential to support aging in place [186,187]. Although both common household technology, like microwaves and electric toothbrushes, and more advanced newer technology, like computer devices and mobile phones, were discussed, this paper elaborates on the latter category for two reasons. First, barriers to buying and using advanced technology are expected to be greater for older adults compared with barriers to accepting regular household technology [33]. These insights can more easily be translated to technology designed to support aging in place. Second, the influence of members of the social network was more obvious when older adults talked about advanced technology.

Methods

A qualitative study was conducted among community-dwelling older adults in a town in the south of the Netherlands. The interviews, on which this paper is based, represent the first measurement of a longitudinal qualitative study. Various informants were asked to bring us into contact with persons aged 70 years and older who were living independently. These informants were asked because they had frequent contact with older people in different roles: they worked for a homecare provider, a local senior volunteer organization, or a tablet pilot project. The tablet pilot project, called "Domovisie", aimed to employ the use of tablets for aging in place by providing older adults with a tablet for one year. The informants were asked to bring us into contact with a varied sampling of people who could be willing to talk about technology in daily life: we aimed to include both women and men, people living alone as well as those living with a partner, and people both with and without a need for care and support. Furthermore, we asked them to only select people who were competent in the Dutch language and who were capable of being interviewed unhampered by cognitive or other problems. To further increase the sample, also included were some people we met at the local shopping center and others we met through the respondents themselves.

In the second half of 2012, 72 potential respondents were informed by letter about the study and invited to participate. Approximately one week after receipt of the letter, the interviewers contacted the potential respondents by phone to answer possible questions, ask for their cooperation, and, if appropriate, make an appointment for the interview. The interview team consisted of two

interviewers, psychologists trained in interview techniques, and two observers, university lecturers with a background in health care. Each respondent was visited at home by an interviewer accompanied by an observer. If a household consisted of more than one person, only one of them participated in the study. In some cases, the spouse was present and, although the interviewers directed their questions to the respondent, spouses sometimes clarified or added insights to the interview. At the beginning of the visit, which lasted between one and a half and two hours, the informed consent form was discussed and signed by the respondent. Subsequently, the respondent was asked whether he/she in the last year had experienced life events that were meaningful to them, using the Social Readjustment Rating Scale (SRRS) [228] adjusted for older adults and to fill in the Tilburg Frailty Indicator (TFI) [189] and the Mini-Mental State Examination (MMSE) [190] to get an impression of both physical and cognitive health status as well as major life events. Although this was never the case in practice, the interview protocol instructed that when a participant scored lower than 24 on the MMSE the interview needed to end [229]. The next step was a tour of the house, in which an inventory was made of the technology present. For each device, frequency and type of use was recorded. After these preparatory activities, a maximum of three devices was selected, based on preferences of participants who sometimes displayed strong feelings, both positive and negative, towards certain devices and on suggestion by the researchers who aimed for variation in devices that were and that were not integrated in the daily lives of older adults. Respondents were interviewed to learn how these specific devices originally came into their home and to understand what influenced both use and non-use. For each device, we asked in an open way about factors that could be of influence. In most interviews, the role of family members, especially of spouses, children and grandchildren, naturally came to the fore. When that was not the case, but there were indications of the influence of the social network, we asked the respondent to further elaborate on that influence. Furthermore, the topic list was based on a systematic review of factors that influence acceptance of technology for aging in place [11].

With permission of the respondent, the interview was digitally audio recorded and transcribed verbatim. In total, five researchers were involved in the coding of the interviews. Each transcript has been coded independently by two of these researchers who discussed their coding to reach consensus. Factors described in the systematic literature review [11] that inspired the topic list, were initially used as sensitizing concepts. Discussions in the coding pairs and in the whole coding team lead to the introduction of new codes, based

on what respondents had told in the interviews. Coding and analyses of the interviews were aimed at understanding influencing factors for technology acceptance, including the effect of the social network. To describe how and why family members influence the acceptance of technology by older adults, we focused on the analysis on codes referring to the role of the social network. Inspired by grounded theory, our analysis was inductive [230]. Analyzing the relevant codes and associated text fragments several times, we discovered that spouses, children and grandchildren have their own reasons for and ways of influencing the purchase and use of specific devices. The reasons and ways of influence were leading in our analysis. We elaborated on those devices that had the potential to learn us about the reasons and ways of influence. The study protocol of the entire longitudinal qualitative study was approved by the Psychological Ethical Commission (PETC) of the Tilburg School of Social and Behavioral Sciences at Tilburg University (EC-2012.04).

Results

Of the 72 potential respondents who were invited to participate in the study, 53 gave their consent, a response rate of 73.6%. At the beginning of three interviews, it was discovered that these respondents were younger than 70 years: two were 69 years old and one was 68 years old. It was decided to include these interviews because their stories fit easily with the stories of our other respondents, and since a considerable drop-out rate in subsequent measurement moments is not unusual, as many respondents as possible had to be included in the first period of data gathering.

Table 1 shows some general characteristics and health indicators of our respondents. Their mean age was 78 years, and 43 (81.1%) of them were between 70 and 85 years. Most (64.2%) were female, which more or less corresponds to the gender distribution in the older Dutch population: 55% of the Dutch population over 65 and 70% of the population over 85 is female [40]. Furthermore, our respondents had relatively little education and the majority lived alone. All respondents reported having one or more chronic conditions. Most often were mentioned: high blood pressure (49.1%), arthritis in hips or knees (47.2%) and severe or persistent pain or limitation in the back (41.5%). One in five experienced mild cognitive problems according to the Mini Mental State Examination (MMSE) and more than half were frail according to the Tilburg Frailty Indicator (TFI), which is similar to the occurrence of frailty in the Dutch population [231].

Table 1. General characteristics and health indicators (N = 53)

Age (Mean 78)	n	%
65–69	3	5.7
70–74	11	20.8
75–79	21	39.6
80–84	11	20.8
85–89	5	9.4
90+	2	3.8
Gender		
Female	34	64.2
Male	19	35.8
Education		
None or primary education	17	32.1
Pre-vocational education	11	20.8
Secondary vocational education	5	9.4
Secondary education	13	24.5
Higher education	7	13.2
Living arrangement		
With partner	15	28.3
Alone	38	71.7
Number of chronic conditions		
0–1	1	1.9
2–3	20	37.7
4–6	20	37.7
7+	12	22.6
Cognitive capabilities according to MMSE		
No cognitive problems (MMSE: 27–30)	42	79.2
Some cognitive problems (MMSE: 24–26)	11	20.8
Frailty according to TFI		
Not frail (TFI ≤ 4)	25	47.2
Frail (TFI ≥ 5)	28	52.8

All respondents, with the exception of two, described the role of members of their social network when talking about technology in their homes and lives. Although spouses were also important, our respondents told us more frequently about the influence of children and grandchildren. For the purposes of this study, the term "children" includes both the respondents' own children

and their children's spouses. Of the 51 respondents who mentioned the role of members of the social network, 11 referred to spouses, while 29 referred to children and 15 to grandchildren.

In the following sections, the influence of the spouses, children, and grandchildren on technology acceptance will be elaborated on. All of these network members appear to have their own ways and reasons to influence respondents' use of computer devices (computers, laptops, and tablets). Therefore, this type of technology is detailed in each of the following sections. The use of other types of technology will be discussed when the role of a specific type of family member became evident. As such, electric bikes, mobile phones, and personal alarms are elaborated on. In general, the influence of both spouses and grandchildren is a natural and coincidental part of their interaction. When one spouse buys and uses a device, the other naturally comes in contact with it. Older adults easily adopt the enthusiasm of their grandchildren for technology, especially computer devices. This also holds true for children. Their influence, however, is also driven by concerns about the well-being of the older adult and is therefore more intentional.

Spouses: Natural and Coincidental

Although fifteen of our respondents lived with their spouses at the time of the interview, eleven explicitly said something about the influence of their spouses on the acceptance of technology. It should be noted that of these eleven, six (two women and four men) were living with their spouses at the time of the interview while the spouses of the other five had passed away. In some cases, the spouses were present during the interview and clarified or added some insights to the conversation. In general, the influence of spouses was rather coincidental; it just happened to be part of their natural interaction when it came to the acceptance of computer devices, electric bikes, and mobile phones. Most spouses supported each other in the acceptance of technology and also exerted intentional influence; some spouses suggested that their partners buy an electric bike because they were convinced it would be better for them. In a few cases, husbands were not supportive of computer use of their spouses.

Computer Devices

The use of computer devices was mostly limited to surfing the Internet, video telephony, and electronic banking. One woman tried Internet dating, but she did not really like it. In general, our respondents preferred a laptop or tablet over a desktop computer placed in a separate room because they preferred to

be together when one of them used a computer device. However, at the same time, they found a personal computer in the living room was too intrusive. The purchase of a computer device often was initiated by just one of the spouses. Although the other spouse originally did not display a manifest interest in this type of technology, he or she would come in touch with a computer device and the Internet by coincidence when this type of technology entered the home. Among our respondents, women were more often the initiator to buy a computer compared with men. Four of the men we interviewed told us that their wives were the reason they owned a computer. A widower who did not have any interest in computer devices at all replied to our question why he had accepted the computer that was given to him and his wife when she was still alive: *"For my wife…otherwise that computer would never have come here."* (Male, 77 years, living alone). Despite his indifference, which was already the case when he had to use a computer at work, he now and then played a game on the computer. Another male respondent followed his children and grandchildren on Facebook, but left the use of the laptop largely to his wife: *"My wife searches the Internet for information about health. I don't."* (Male, 73 years, living with wife). When explaining their considerations for joining the tablet pilot project "Domovisie" one man said: *"In the beginning, when I heard of it, I thought, "That could be something for my wife."* (Male, 85 years, living with wife).

Spouses were not always encouraging and could also complicate the purchase and use of a computer device. One woman, for example, was considering to get her own website to show the art she made, because frequently people asked for her website and she expected to be asked for expositions more often. However, her husband was not in favor; he wondered who knew his wife and would search the Internet for information about her and her work. In other cases, spouses were a little bit more curious, but in the end did not really use the computer devices. When we asked one of our male respondents if he ever did anything with the tablet that his life partner, who had recently passed away, had purchased, he said: *"I solely had a look to know how it works and what it is."* (Male, 68 years, living alone). Later in the interview he said: *"I do not use that thing [tablet]. That little device has just entered the home and she has learned to use it, I did not interfere with it."* (Male, 68 years, living alone).

Electric Bike

Seven of our respondents told us about their considerations to buy an electric bike; six of them owned one. Three married men and one widowed woman

spoke of the influence of their spouses in buying and using such a bike. For respondents who liked to cycle, an electric bike was appealing because it lightened this enjoyable activity that could be physically quite fatiguing, particularly when the people they cycled with had one. None of the respondents who owned an electric bike had been unable to cycle before purchasing one. Our respondents told us that their electric bike helped them to be active and healthy and enhanced daily activities like grocery shopping and visiting family or friends.

One woman bought such a bike because her husband, who was so ill that he was lying in bed in the living room, insisted and argued that it would be better for her knees. As a result, she enthusiastically used the electric bicycle to visit her family and also just enjoyed riding the bike for its own sake.

When the spouse already owned an electric bike, it was natural to purchase such a bike oneself, because it was rather physically demanding to cycle with someone riding a bike with an electric motor when riding a regular bike oneself. Two respondents mentioned this to explain why spouses of older people with such a bike also decided to buy one, sometimes strongly encouraged by their spouse. *"And certainly when we cycle together, then it is certainly enjoyable. Because she has a speedy tempo and, on a regular bike, I have to pedal intensively to keep up with her. I had just bought a new regular bike, half a year ago. She said to me, "Come on, please buy an electric bike". And then I thought, "Yes, it would be nice to also have an electric bike". Now, I would not want to miss it anymore."* (Male, 74 years, living with wife). After a fall and three to four months of recovery, another respondent did not expect to be able to drive a car or cycle once again. When he was able to cycle again, he wanted to buy a new bike and his wife gave the following advice: *"My wife said, "Since you grow older, it is better to buy an electric bike".* (Male, 81 years, living with wife).

Mobile Phone

Many of our respondents owned a mobile phone, but rarely used it. It provided them with the certainty to be able to call someone or to be called when necessary, wherever they were. For many of our respondents, the use of a regular mobile phone, not a smart phone, was rather challenging. One of our respondents, for example, went back to the store because his phone did not work anymore and discovered that a mobile phone needs recharging. Sometimes each of the partners owned and used a mobile phone; more often, they owned one together and one of the spouses was more skilled in its use.

Although one of our female respondents used their mobile phone to call her family, her husband always keyed in the number. He said: You can't say that you use it yourself. (Husband of female, 78 years).

Children: Natural and Intentional

The narratives of the 29 respondents that elaborated on how children influenced their use of technology learned that this influence was multifaceted. In many cases, children helped their parents purchase and use certain technology. This natural influence was often accompanied by a more intentional influence. Out of concern, children aimed to convince their parents to use certain technology like a mobile phone or a personal alarm. Many of our respondents understood their children's worries and were therefore also willing to accept technology that they initially did not prefer, while others had the feeling that their children forced their ideas upon them. The role of children in technology acceptance was most obvious for computer devices, mobile phones, and personal alarms. In elaborating on these devices, we do not differentiate between children and the children's spouses because in providing advice or support about technology the expertise and experience of someone was more important than the presence of a blood tie.

Computer Devices

Children influenced the acceptance of computer devices in various ways. Thanks to their children, older adults got to know the possibilities of computer devices, which could give rise to the intention to purchase one. Often, children facilitated it, sometimes they advised against it, and sometimes our respondents felt pushed by their children to buy a computer. When respondents became aware of an appealing function of a computer device, they were willing to give it a try. For example, respondents who originally wanted to avoid computer devices in their homes, changed their minds when children or grandchildren who lived far away used video telephony to stay in touch.

Seeing their children and grandchildren using a specific computer device triggered the wish in older adults to own this kind of technology themselves. One respondent literally said (with a laugh): *"When my children have something, I have to have it also. No, that is just a joke. … I saw it with my children, the tablet, even my grandson who is three years old works with it—he is my great-grandson. When you see it, you think "That is handy". It is light enough to take it with you. I think it is the invention of the century"*. (Female, 83 years, living alone). For some respondents, the wish to go along with

current developments and to not lose connection with society was a reason to buy a computer device. Usually, children encouraged their parents, but we also noticed that some older adults felt pressed by their children, while other children advised against it. One woman answered our question why she and her husband had bought a computer as follows: *"My son insisted on it. My husband was not in favor of it, and I was totally not in favor, but all right, you cannot do without it anymore, you have to."* (Female, 78 years, living alone). However, it could also work the other way around. Although the daughter of the following woman was against it, the woman went to the store with her son-in-law to buy a tablet: *"My daughter said, "Mum, don't start with it. A tablet—what do you want to do with it?"* I said, *"Well, I don't know"*. Then my son-in-law said, *"If your mother wants a tablet, I will join her to the store to buy one"*. (Female, 77 years, living alone).

Many of our respondents found it difficult to (learn to) use a computer device. Their children were much handier with them, and most of our respondents asked them for help when necessary: "*When my computer does not work, my son comes and he fixes it."* (Male, 77 years, living alone). Sometimes, help was provided via telephone, as one woman explained: *"When I wonder, "How does it work again?", then I call them. Yesterday, a very simple thing: the font size was too small. They told me to tick a specific box. And then I think, "Yes, I knew it, but I just lost it for an instant".* (Male, 85 years, living with wife).
A few of our respondents told us about their reluctance to ask too much of their children because they did not want to trouble them. When we asked one of our female respondents if she could ask her sons for help, she answered: *"No, they all live too far away—that is not an option. And my daughter is more nearby, but she also knows little about it. Yes, her husband knows, but I do not want that. I do not want to trouble them."* (Female, 81 years, living alone).

Mobile Phone

Of the 22 respondents who discussed having a mobile phone in their lives, eight spoke about the influence of their children on accepting the mobile phone. For the children of four of our respondents, it is a reassurance when they had a mobile phone and brought it with them when leaving their home. Although they felt somewhat pressed, they understood the concerns of their children; reassuring the children was enough reason to accept a mobile phone. This acceptance seemed to be incomplete; they owned a mobile phone and carried it with them, but rarely used it. Children also kindly stimulated the

acceptance of a mobile phone by purchasing it together or giving advice. In general, our respondents carried a mobile phone to be sure they could call for help if needed. For one of our respondents, the worries of his daughter about him cycling without carrying a mobile phone was the reason to buy one. He carried it and recharged it but at the time of our interview had never used it. In addition, a serious life event could directly cause the children to insist that their parent(s) buy a mobile phone. One of our respondents told us: *"After the first CVA [cerebrovascular accident], my daughter said, "Mum, you have to buy a mobile phone". Then she gave me one. The children told me to take it with me when I am outside with my mobility scooter."* (Female, 77 years, living alone). Although her children were rather forceful, she agreed with them because she knew her mobility scooter could break down. Another woman was very short about the reason why she owned a mobile phone: *"My son instructed me to do so."* (Female, 78 years, living with husband). Many children gave their parent(s) a mobile phone as a present. Some older persons appreciated this gift while others felt pressured and were not really happy with it.

Personal Alarm

Contrary to the other technologies examined, a personal alarm only has a prevention and care function and no other appealing uses. Several respondents who did not have a personal alarm mentioned that they would feel really old when in need of a personal alarm. Respondents who did have a personal alarm stressed the feeling of safety; they were certain that they could call for help when needed. Ten of our respondents spoke about the personal alarm that they used. A serious life event, such as a fall or the death of the spouse, combined with worries of their children gave people enough reason to accept a personal alarm. Some older adults felt somewhat pressed by their children, but they mostly acknowledged that they themselves also felt safer as a result. One respondent answered as follows when she was asked how necessary the personal alarm was for her: *"Well, because my children insisted. I think, it is to reassure them."* (Female, 80 years, living alone).

Grandchildren: Natural and Coincidental with Pride and Joy

Fifteen older adults addressed the influence of grandchildren. This was most apparent for computer devices, probably because the gap in knowledge and skills between our respondents and their grandchildren was largest in this domain. The enthusiasm of grandchildren for computer devices and applications was very prominent. Grandchildren were a trigger to buy a

computer device and to use specific applications like video telephony and social media. Furthermore, grandchildren were a natural source of support. Older adults displayed pride and pleasure when talking about the abilities of their grandchildren.

Computer Devices

Due to the enthusiasm of their grandchildren for computer technology, older adults were willing, maybe even eager, to buy and use a computer device. Referring to the decision to participate in the tablet pilot project "Domovisie", a woman said: *"The grandchildren also said, "Grandma, that's great! You should do it, we will help you" and I thought, "Yeah, why not? What could stop me?"* (Female, 79 years, living alone).

The following quotation shows that the enthusiasm of the granddaughter about a tablet was a stronger facilitator for this respondent than the skepticism of the daughter was a barrier. However, although this respondent referred to this kind of technology as "nonsense", she decided to participate in the tablet pilot project "Domovisie": "*My granddaughter says, "Grandma, you should do it—it's cool". But my daughter says, "Ma, you won't understand it; it is of no use to you."* (Female, 77 years, living alone). Computer devices provided opportunities to interact with grandchildren via, for example, video telephony applications or social media. In particular, grandchildren living abroad were a reason to buy a webcam and use video telephony. For several respondents, interaction with the grandchildren was the most important reason to have a computer and use social media. The following quotation illustrates this importance; even when people did not really like or were not really interested in social media, they used it to stay informed about the lives of their grandchildren. *"Respondent: In certain things we are not interested. Interviewer: Can you give an example? Respondent: The communication via Facebook and via Twitter. I have an account for my grandchildren; then I see something of their lives. But I do not post messages myself."* (Male, 73 years, living with wife).

Grandchildren were also willing to facilitate the use of computer devices; they demonstrated the possibilities (e.g., certain games), installed applications, and helped when necessary. Although they were often too fast when showing how to do something, respondents appreciated this support very much and were hardly reluctant to accept help from their grandchildren. Having the opportunity to ask grandchildren for help provided respondents with comfort and pride, as illustrated in the following citation of a grandfather: *"My*

grandson, he is eleven, will support me. He really knows how to use it. He knows how to search for apps. He says, "Look grandpa, these are for free and for these you have to pay", and then he has a whole list. Yeah, he's good at this. I like it very much." (Male, 76 years, living with wife). The grandchildren of the following respondent taught her much about the use of her computer. They are an anchor for her and she proudly tells about it: *"I only have to call him to get him in for help. My other grandson is younger, but he might be even more clever with the computer."* (Female, 69 years, living alone).

Discussion

In answering our research question - *"Why and how do family members, including spouses, influence the acceptance of technology by community-dwelling older adults, according to older adults themselves?"*- an addition can be made to the scarce body of literature about the perspective of older adults regarding the influence of family members on technology acceptance. Our results show that the acceptance of technology by older adults, in the sense of purchasing and using devices, is not an individual matter; it is influenced by spouses, children and grandchildren, as was earlier established in the Netherlands [43], also in other parts of the world [232,233].

Each category of family members has its own reasons for and methods of influencing. Interest in, purchase of, and use of technology by older adults is influenced by both spouses and grandchildren as a natural and coincidental part of their interaction. When they interact, they also coincidentally see each other's devices, talk about the devices' possibilities, and can try them. This is in line with more general theories that suggest that adoption of new behavior and/or technologies is facilitated when individuals can see and try it [178,217]. Often, this nourishes the interest of older adults in technology. Although interactions with spouses are more frequent than with grandchildren, pleasure and entertainment are important facilitators when it comes to influencing technology acceptance in both these relationships. However, the interaction between spouses sometimes also has some intentional aspects.

In general, but not always, spouses are supportive of each other: they persuade or stimulate and help each other in buying or using a specific technology. They naturally come into contact with each other's devices and may become convinced of the usefulness of it. Furthermore, they are a natural, and often available, facilitator and source of support. Spouses ride their electric bikes together. Sometimes, they even complement each other when using certain devices; for example, one man keyed in the number when his wife wanted to

call someone with their mobile phone. The question remains of what happens when one of the spouses dies: Will the other then still ride the electric bike and use the mobile phone, or would that be too much of a challenge? Our results indicate that after the decease of the spouse older adults might not always continue using devices that their spouse brought into the home, but sometimes they do. Therefore, it would be interesting to further study this in future longitudinal research.

Spouses and grandchildren influence technology acceptance of older adults in a rather unintentional way; it is a natural and coincidental part of their regular interaction. This holds true for the influence of children as well, but their influence also has more intentional aspects and is partly driven by concerns. For example, mostly out of concern, children strongly advise their parents to use a mobile phone. Sometimes, a mobile phone is given as a present, which is appreciated by some, while others feel that it is forced upon them. Older adults are rather submissive when they can diminish their children's worries by adapting to certain technology like a mobile phone or even a personal alarm. Especially when it concerns technology that is not specifically designed for older adults, like a mobile phone, they follow their instructions and rarely go their own way in buying or using technology when their perspective deviates from that of their children. This is more complex when it concerns devices specifically designed for older adults, like a personal alarm, that might have a stigmatizing effect. In those cases, older adults weighed the tradeoff between personal feelings of safety and worries of their children and the possible stigmatization. Many of our respondents have assumed an adaptive management strategy to cope with needing help. Characteristic of this strategy is the adaptation to others' views about what is necessary. Positive or negative feelings are invoked by the matching of the arranged support and the needs as experienced by older adults themselves [206].

In general, older adults are reluctant to ask too much of their children. Other research suggests a delicate trade-off between maintaining independence and following the opinion of their children. Older adults do this, also because they want to avoid burdening their children [135,224]. Additional studies have revealed the importance of social relationships for older adults and the reluctance to burden their children [195,207,208,220,234]. We also found such indications but can add that older people hardly are reluctant to ask their grandchildren for help. The enthusiasm and help of grandchildren is a clear facilitator in the acceptance of technology by older adults. Filled with pride, older adults tell about the enthusiasm and the abilities of their grandchildren in using computer devices and about their willingness to help when problems

arise. Facilitating communication and being informed about the lives of family members, especially grandchildren, is the main reason for older adults to use video telephony or have an account on social media. The results of our study are summarized in Table 2.

Table 2. Summary of results

Older Adult—Spouse: Natural and Coincidental
• Both advise each other on what to (not) use • Both can initiate purchase • Both can help each other in using technology • Use by older adult may lead to use by spouse, and vice versa • Together they form an implicit or explicit agreement on who uses what
Older Adult—Children: Natural and Intentional
• Children advise and help older adults, typically not the other way around • Use by children may lead to use by older adults, typically not the other way around • Children either help older adults in buying technology, or they buy it for them • Children may be inclined to push their parents to use technology, out of concern • Older adults may be inclined to use technology for the sake of their children • Older adults may be inclined to not put a burden on their children
Older Adult—Grandchildren: Natural and Coincidental with Pride and Joy
• Grandchildren advise and help older adults, typically not the other way around • Use by grandchildren may lead to use by older adults, typically not the other way around • Grandchildren influence older adults by their enthusiasm • Older adults are typically not reluctant to ask their grandchildren for help • Older adults are proud of their grandchildren's technology related skills

When comparing our findings to existing technology acceptance models, it becomes apparent that current models offer a limited take on how and why family members influence older adults' technology use. For example, the most dominant model - the Technology Acceptance Model (TAM) - only incorporates one social variable: subjective norm (i.e., the degree to which an individual perceives that important others believe he or she should use the new system) [47]. This limitation of TAM was put forward by the original author [47] and is confirmed by our study, which shows that other types of social influence besides subjective norm play a role in the acceptance of technology by older adults, such as the help and support offered by family members. The notion that support may facilitate use is acknowledged by the Unified Theory of Acceptance and Use of Technology (UTAUT) [48,57], which is generally considered to be the successor to TAM. UTAUT incorporates facilitating conditions, which are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system [48,57]. However, our study shows that the mere belief that support is available is not enough to facilitate use by older adults; older adults

also need to be willing to call upon their relatives to help them.

It is important to note that several authors have attempted to extend TAM, in order to form models that are more suitable to the context of older adults. One example is the Senior Technology Acceptance Model (STAM), as described by Renaud and van Biljon [235]. This model, which is aimed at predicting acceptance of mobile phones by older adults, also entails social influence. According to the authors, their concept of social influence aligns with a variable which is part of Rogers' classic theory of Diffusion of Innovations (DOI): observability. Observability can be defined as the extent to which the results of using a technology are visible to others [178]. This is in line with the findings in the current study, in which we have also found that the use of technology by family members influenced the use of technology by older adults. However, STAM as described by Renaud and van Biljon, does not make explicit other types of social influence [235]. In addition to Renaud and van Biljon [235], Chen and Chan [236] have also proposed and tested a model, which they also call the Senior Technology Acceptance Model (STAM). The study by Chen and Chan [236] showed that satisfying and supportive personal relationships, as well as a high level of social activity, can have a positive effect on the self-reported use of various types of technologies by older adults. However, Chen and Chan [236] have not added or tested variables that can explain how and why personal relationships and social activity can affect technology use.

All in all, it seems that none of the abovementioned models captures all of our findings: the various ways in which family members influence technology use by older adults are scattered across various models. Moreover, none of the abovementioned models captures the underlying motivation of family members who influence technology use by older adults. This paper was limited to the role of family members in technology acceptance of older adults. It should be noted that we asked our older respondents in an open way about the purchase and (intended) use of technology and factors that could be of influence. Although we did not explicitly ask about the role of spouses, children, or grandchildren, in most interviews, these roles naturally came to the fore, far more extensively than did the roles of other family members or peers. However, focusing explicitly on the role of family members is expected to provide additional valuable insights. Focusing on the role of the whole network is also important because the number of people growing old without children and grandchildren - or with children living at a greater distance - increases.

Furthermore, it should be noted that, in some cases, spouses were present during the interview. And although interviewers directed their questions to

respondents, spouses sometimes clarified or added insights to the interview. This was helpful in understanding factors that influence technology acceptance, but it of course also influenced our results. However, to support a confidential environment for the interview, we do not think it is feasible to ask the spouse to leave the room during the interview.

While our study adds to the current literature by focusing on the behavior of older adults (i.e., technology use) instead of just on their intention to use technology [11,53,152], it should be noted that we measured self-reported use. Research shows that studies based on self-reported use may show different results with studies employing direct usage measurement (i.e., actual usage) [53,237]. This implies that the findings in our study cannot readily be compared with findings from studies that measure actual usage. Additionally, it cannot be ruled out that our self-reported (subjective) measurements of use are biased (i.e., participants may have overestimated or underestimated their actual use) [237]. The current study indicates several directions for further research in addition to those mentioned before. To fully understand social dimensions of technology acceptance, it would be worthwhile to study the role of all members of the social network from the perspective of both older adults themselves and members of their social network. Such studies should focus on the social network in a broad sense, including peers, friends, but also professionals like general practitioners or caregivers and should focus on both motives and actions. Besides, it would be interesting to study the impact of members of the social network. Could a supportive network help to overcome difficulties in technology or help older adults to become more convinced of their own capacities? In addition, it would be of value to study the attitudes and opinions of various stakeholders (including older adults) involved in use of technology. This provides insight in how attitudes and opinions influence technology use. This is especially interesting when attitudes and opinions are conflicting between older adults and members of their social network.

Conclusions

Our study reveals the importance of including family members when implementing technology in the lives of older adults. Because our study shows that parents are willing to try to use technology when their children are convinced of its positive effects, it is obvious that children should be provided with information about the value and use of devices to be implemented. Many children worry about their parents, so they will probably be ambassadors of certain technology when it helps to diminish their worries.

Our study also indicates that it could be of added value to determine an appropriate role of grandchildren when trying to stimulate technology acceptance by older adults. Grandchildren are both approachable and often skilled at working with technology, even at a (very) young age. Furthermore, older adults easily adopt their enthusiasm for technology; indeed, they are more willing to accept technology that their grandchildren like. This will not be the case for specifically designed assistive technology, but grandchildren can probably have a facilitating role when it comes to applications running on a regular tablet, smart phone, or other computer devices. Exploring the potential of the role of grandchildren for technology acceptance by older adults might also diminish the burden for children.

Part III

Dynamics in technology use by older adults who are aging in place


1-KHB-06

7

Origins and consequences of technology acquirement by independent-living seniors: towards an integrative model

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Abstract

Background Living independently can be challenging for seniors. Technologies are expected to help older adults age in place, yet little empirical research is available on how seniors develop a need for technologies, how they acquire these technologies, and how these subsequently affect their lives. Aging is complex, dynamic and personal. But how does this translate to seniors' adoption and acceptance of technology? To better understand origins and consequences of technology acquirement by independent-living seniors, an explorative longitudinal qualitative field study was set up. **Methods** Home visits were made to 33 community-dwelling seniors living in the Netherlands, on three occasions (2012-2014). Semi-structured interviews were conducted on the timeline of acquirements, and people and factors involved in acquirements. Additionally, participants were interviewed on experiences in using technologies since acquirement. Thematic analysis was employed to analyze interview transcripts, using a realist approach to better understand the contexts, mechanisms and outcomes of technology acquirements. **Results** Findings were accumulated in a new conceptual model: The Cycle of Technology Acquirement by Independent-Living Seniors (C-TAILS), which provides an integrative perspective on why and how technologies are acquired, and why these may or may not prove to be appropriate and effective, considering an independent-living senior's needs and circumstances at a given point in time. We found that externally driven and purely desire-driven acquirements led to a higher risk of suboptimal use and low levels of need satisfaction. **Conclusions** Technology acquirement by independent-living seniors may be best characterized as a heterogeneous process with many different origins, pathways and consequences. Furthermore, technologies that are acquired in ways that are not congruent with seniors' personal needs and circumstances run a higher risk of proving to be ineffective or inappropriate. Yet, these needs and circumstances are subject to change, and the C-TAILS model can be employed to better understand contexts and mechanisms that come into play.

Background

"In the end, my mother decided to buy herself an iPad... For years, my suggestion that my mother should get a tablet has fallen on deaf ears. Then, her trusty old PC broke, a friend sang the praises of her own tablet, and the next thing I know, she is Facetiming me." [238]

Older adults are often considered 'laggards' and 'resistant' when it comes to acquiring technology [185,187]. Yet, the above fragment from a BBC news article titled *"The generation that tech forgot"* [238] demonstrates that certain events and developments in the life of an older adult can trigger the purchase of technologies. The example above also raises several questions. Apparently, two events triggered the purchase of the iPad: the breakdown of the PC, and the recommendation by a friend. If just one of these events had occurred, would the purchase still have taken place? Additionally, why did the older adult not just replace her broken PC, instead of purchasing an iPad? Furthermore, many sons and daughters of older adults are trying to convince their parents to use technologies such as mobile phones, computers and personal alarms [106,194,239]. What would have happened if the author of the article, and daughter of the older adult, just had given her mother the iPad? Would her mother be just as motivated to use it and take benefit of it?

Understanding the origins and consequences of seniors' acquirement of technology is important from both a healthcare (demand) and a business (supply) perspective. All around the world the number of older adults is increasing. In the more developed regions, 24% of the population is already aged 60 years or over, and that proportion is projected to reach 29% in 2030 and 33% in 2050 [17]. Globally, the number of people aged 80 years or older is growing even faster. In developed regions, 5% currently is aged 80 years or older. In 2050 this will have doubled to 10% [17]. The inevitable increase of the number of seniors in our society poses challenges as well as opportunities. Looking at healthcare demand, governments are rightfully concerned about the sustainability of current healthcare systems [240]. In response, policy makers aim to enable and facilitate independent living of older adults within the community (i.e., aging in place) [2]. This strategy is expected to avoid expensive institutional care of older adults, and to provide a means to cope with the anticipated shortage of care professionals [240,241]. As part of this strategy, deploying technology that enables independent living by older adults

is considered important [71,72,181,241,242].
From a business perspective, the older consumer market has, in general, long been considered uninteresting and irrelevant [19,243–245]. However, the trend towards 'helping older adults to age in place' has also sparked a wave of new technology products, often developed by start-ups and small and medium-sized enterprises, but also by established multinationals [12,18,246]. These technologies are referred to as gerontechnology, ambient assisted living technology, smart home technology, or eHealth. They are usually aimed at supporting or enhancing activities of daily living, personal health or safety, mobility, communication, and physical activity [11]. Specific examples include personal alarm systems, vital signs monitoring and fall detection devices, mobile phones specifically designed for seniors, and medication reminders [11,194]. However, adoption rates of these technologies are reported to be low [11,25–27]. In general, older adults' adoption of technology can be described as a *"complex issue that is affected by multiple factors"* [63]. Several studies provide an overview of factors that play a role, including various technology-related beliefs, alternatives to technology use, technology related skills, benefits and costs of technology use, personal characteristics such as health status, and social influences [11,43,63,194]. However, insight in the interplay and dynamics between factors is very limited. As noted by others, we still do not know very much about when, how and why community-dwelling older adults acquire technology [18,33–35,247]. Additionally, from both a healthcare and business perspective, the ultimate goal is to develop and deploy technologies that contribute to the quality of life of older adults [34,247,248]. Since many technologies fail to reach their intended audience, it is important to develop fundamental knowledge on how older adults develop a need for technologies, how they acquire these technologies, and how these technologies subsequently affect their lives.

Understanding technology acquirements by seniors

Previous research among seniors points to several aspects that need to be taken into account, when aiming to understand the origins and consequences of their technology acquirements. First, the older adult population is highly heterogeneous [44–46]. Within the gerontological literature, there is ample evidence demonstrating increases in physical, sociological and psychological variability with age [249–251]. Therefore, older adults should not be treated and approached as a single homogeneous group [19,44,243,244,247,252]. Second, as people grow older, they go through changes that affect their need

for technologies, as well as their perceptions and responses to technology products [243,253]. According to consumer psychology literature, older adults do not only vary with regards to their values, attitudes, needs and wants [19], but also with regards to how these are affected by aging, life events, and changes in their social and physical environment [34]. The older people get, the more difficult it becomes to cope with these changes, and the more difficult it becomes to continue to age in place [7]. However, research on the experiences and preferences of independent-living older consumers is scarce. Third, many acquirement decisions of older adults are unlikely to be made in isolation [245,247]. Previous studies indicate that family members and peers play an important role in older adults' adoption of technology, particularly by offering advice and support [11,43,63,106,194,239,254]. Additionally, relatives may buy technology products for older adults [43,106]. However, older adults and relatives do not always see eye-to-eye with regards to the older adults' need for acquiring technology [43,106,194]. Currently, it is unclear how the influence of family and peers during the acquisition process subsequently affects older adults' use of technologies.

Research aims

The current study aimed to understand the origins and consequences of technology acquirement by independent-living older adults. We did this by exploring: (1) how and why technologies are acquired by independent-living older adults; and (2) the implications of the ways in which independent-living older adults acquire technologies. In this pursuit, we appreciated that older adults are diverse, that their lives are subject to change, and that their acquirement of technology may be influenced by their family and friends.

Methods

Design

To capture both the origins and consequences of technology acquirement, a prospective and explorative longitudinal qualitative field study was carried out [255–257], which involved home visits to independent-living older adults on three occasions (t_1, t_2, and t_3; 2012-2014). The Ethics Review Board of the Tilburg School of Social and Behavioral Sciences approved the study.

Sampling

In 2012, a purposive sample of independent-living older adults with different health statuses, living arrangements, and levels of technology experience was recruited. Sources of recruitment were home care providers, a senior volunteer organization, a local tablet computer pilot project, a local shopping center, and word of mouth contacts. Inclusion criteria were: (1) independently living at home, (2) aged 70 or older, (3) Dutch nationality, and (4) no cognitive impairment as measured by the Mini-Mental State Examination (MMSE) [190] using a score of 24 as cutoff [229]. All participants were living in the same medium-sized city in the Netherlands, and one participant was included per household. Potential participants were first handed an information letter, and were telephoned to schedule the first home visit after they expressed an interest in participating in the study. Of the 72 approached individuals, 53 agreed to participate (N = 53, t_1). Over the course of the study subsequently 18 and 2 participants dropped out (N = 35, t_2; N = 33, t_3). Reasons for drop out were: not interested in continuing (n=5), deceased (n=4), somatic health problems (n=4), cognitive impairment (n=2), too busy providing informal care for their partner (n=2), no longer living independently (n=2), and lost contact (n=1). For the study reported here, only individuals who participated in t_1, t_2 and t_3 were included (N = 33).

Data collection

At the beginning of the first visit (t_1), informed consent was acquired. Prior to the second and third visit (t_2, and t_3), participants were informed by letter on the research project's progress, and participants were called to schedule a home visit at their convenience. Home visits were performed by pairs of researchers (SP, MN, SA, CvdV, and MR).

The aim of the data collection at t_1 (September – December 2012) was to understand participants' lives, and their perceptions and attitudes towards technologies. For this purpose, we performed three types of data collection: (1) background information on 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) [189], and cognitive functioning as measured by the Mini-Mental State Examination (MMSE) [190]. Additionally, participants were asked whether they had experienced life events that were meaningful to them in the last 12 months; (2) participants and visiting researchers jointly made a tour through the home, in which an inventory was

drawn up of electronic devices. Devices were included if they required electric power in order to function, were intended to be used in or around the home, and could support activities of daily living, personal health or safety, mobility, communication, and physical activity. Ownership and type and frequency of use were recorded; (3) semi-structured interviews were conducted in which participants were interviewed on their perceptions and attitudes toward the devices that were in their home, as well as reasons for ownership and level of use. In particular, we were interested in technologies that were integrated in the daily lives of participants, as well as technologies that were not, or to a lesser extent. Initially, a topic list based on our systematic review of factors influencing acceptance of technology for aging in place was used [11]. As data collection progressed, the topic list was adjusted. Participants were offered a magazine subscription of their choice at the end of the visit. Subscriptions lasted until the end of the study (also for participants who dropped out).

At t_2 (May – July 2013) and t_3 (March – June 2014) data collection was aimed at understanding why participants acquired new devices since t_1, and at investigating participants' experiences with new devices after acquirement. First, the same type of background information on participants as in t_1 was gathered. Secondly, participants were asked whether they had acquired electronic devices since the last visit. We recorded the date on which each new device was acquired, and the frequency of use at the time of the visit. Lastly, a semi-structured interview on the acquirement of devices was conducted. We were particularly interested in understanding the timeline of acquirements, and the people and factors involved in acquirements. Additionally, participants were interviewed on their experiences in using devices since acquirement, focusing on their satisfaction with the device, and the implications of using it. When a participant had acquired many devices, we selected a number of devices to discuss, aiming to include various types. During the interviews, we took into account the background information that was gathered on each participant, and relevant themes which had emerged in previous interviews with the participant. The topic list used in the interviews was based on the topic list used at t_1, and evolved as data collection progressed. In this stage of the data collection, we made sure that at least one of the two visiting researchers had visited the participant before. All interviews were audiotaped and transcribed verbatim by a professional transcription service.

Analysis

Qualitative analysis of transcripts entailed two phases. In the first phase, thematic analysis [258,259] was employed by a pool of six researchers (SP, KL, MN, SA, CvdV, and MR). The thematic analysis process took place during and between all three waves of the data collection, and was supported by the use of qualitative data analysis software (Atlas.ti version 6 and 7). In this process, we studied transcripts and attached inductive codes to quotations relevant to the research questions. To increase our understanding of the data, all t_1 transcripts, two-thirds of the t_2 transcripts, and one-third of the t_3 transcripts were first coded independently by two different researchers from the pool of six (in alternating pairs). We aimed to have transcripts analyzed by a researcher who was present at the interview, and a researcher who was not, to fuel discussion. The two researchers discussed their analyses, and produced a single coded version of each transcript. Periodically, these coded transcripts were combined into one Atlas.ti file by SP. This file was used in group sessions in which new codes were discussed, and overarching themes of codes were formed. Soon after the analysis of the t_1 transcripts, few new codes were added, which indicated that data saturation was reached with regards to which factors and themes had influenced ownership and level of use of technology. However, in order to understand the dynamics and interplay between these factors and themes over time, an additional phase of data analysis was necessary.

In phase two of the analysis, the dynamics and interplay between factors and themes were analyzed by SP, KL, HV and EW, using a realist approach [260,261]. Central to this approach is the idea that a specific context (C) can trigger or enable a number of mechanisms (M), and that combinations of C and M lead to certain outcomes of interest (O). This can be explained by the analogy of gun powder; *"When a spark is introduced to gun powder, the chemical composition of gun powder (mechanism) results in an explosion (outcome). However, there are no explosions if the context is not right—damp conditions, insufficient powder, not adequately compact, no oxygen present, duration of heat applied is too short (context)"* [262]. The realist approach is particularly suitable for gaining understanding on how and why outcomes of interest originate, and in what circumstances [263,264]. As such, this approach is fitting for our study, in which we sought to understand origins (context, mechanisms) and consequences (outcomes) of technology acquirement by independent-living older adults. In using the realist approach, our work focused on distinguishing contexts, mechanisms and outcomes out of the factors and themes that had emerged

during the first of phase our qualitative analysis. For this purpose, SP applied constant comparison [265], systematically comparing technology acquirements by each participant, and between participants. In this iterative process, insights and findings were discussed with KL, HV, and EW on a regular basis.

Member checking

Member checking took place in two ways. First, in order to promote descriptive and interpretative validity [266], a summary of each interview was sent to participants shortly after t_1, t_2 and t_3. On one occasion, a participant felt she was misinterpreted during an interview. This was discussed with the participant, and taken into account during data analysis. On all other accounts, participants had no remarks with regards to the summaries.

Second, as an additional step, extra home visits were made to participants in June and July 2015. The goal here was to promote theoretical validity [266], and the sole purpose of these extra visits was to share and discuss our interpretations of the interview data across the entire study. With participants, we discussed findings that were particular to them, including acquirement patterns and processes. Additionally, we discussed characteristics that were typical to the participant or his or her situation. Furthermore, we illustrated to them how they –in our eyes- differed from other participants. The discussions helped us in shaping our conceptual model. Out of the 33 participants, 25 participated in this final member check. Reasons for not participating were: personal health problems (n=3), deceased (n=3), and lost contact (n=2). All participants recognized themselves very well in our descriptions of them and their acquirements of technology. Participants would sometimes add specifics that were in line with our analysis. These were recorded, but did not alter our conclusions.

Results

In the following paragraphs, we first describe the characteristics of the sample. Next, we describe the origins (i.e., context and mechanisms) and consequences (i.e., outcomes) of technology acquirements by participants. In our description of the origins of technology acquirement, we discern between the status quo of participants prior to acquirement, decisive developments within that status quo, and acquirement enabling mechanisms. In the last two paragraphs, we describe the number and types of acquirements by participants, and favorable and unfavorable consequences of technology acquirements. In the discussion section, a new conceptual model that captures the aforementioned is presented.

Sample

The sample consisted of 33 participants who were aged in their seventies and early eighties (Table 1). There were more females than males in the sample, and the majority lived alone. Most participants had attained some form of secondary education and received homecare, although the latter fluctuated during the study. A vast proportion of the participants considered their health good, very good, or excellent, although this number dropped at t_3. The participants' frailty (TFI) score, which potentially could range between 1 and 15, was lowest at t_2, and highest at t_3. The participants' cognitive functioning (MMSE) score, which potentially could range between 0 and 30, remained stable around 28, indicating normal cognitive functioning among participants.

Table 1. Sample characteristics (N=33)

	t_1	t_2	t_3
Age: mean ± SD, in years	76.[1] ± 3.91	76.6 ± 4.0	77.5 ± 3.9
Gender			
Female: n (%)	20 (60.6)		
Male: n (%)	13 (39.4)		
Education			
None or primary: n (%)	9 (27.3)		
Secondary: n (%)	20 (60.6)		
Higher: n (%)	4 (12.1)		
Living arrangement			
Alone: n (%)	21 (63.6)	22 (66.7)	22 (66.7)
With a partner: n (%)	12 (36.4)	11 (33.3)	11 (33.3)
Receiving home care: n (%)			
Yes: n (%)	19 (57.6)	22 (66.7)	21 (63.6)
No: n (%)	14 (42.4)	11 (33.3)	12 (36.4)
Subjective health			
Good, very good or excellent: n (%)	23 (69.7)	23 (69.7)	20 (60.6)
Fair or poor: n (%)	10 (30.3)	10 (30.3)	13 (39.4)
TFI score[2]: mean ± SD	4.3 ± 2.7	3.8 ± 2.4	4.6 ± 2.6
MMSE score[3]: mean ± SD	28.1 ± 1.5	28.5 ± 1.5	28.2 ± 1.5

[1] During the home visits, one participant mentioned he was 68 years old, and another participant mentioned he was 69 years old. Both participants were not excluded due to ethical considerations.
[2] As suggested by Gobbens et al. [189], a Tilburg Frailty Indicator (TFI) score of 5 was used as the cut-off point for frailty.
[3] As suggested by Kempen, Brilman and Ormel [229], a Mini-Mental State Examination (MMSE) score of 24 was used as the cut-off point for cognitive impairment.

Status quo prior to acquirement

Looking at the context from which acquirements originated, analysis showed that six major components captured participants' ownership and use of technology at t_1 (Table 2). Taken together, we label these components the status quo (i.e., the current state of affairs). As will be explained in more detail later, developments in these components at t_2 and t_3 could induce technology acquirements among participants.

Table 2. Major components of the status quo prior to acquirement

Challenges of independent living
Use of technological and non-technological means
Internal technology related schemas and attitudes
External influence of the social network
External influence of organizations
Physical environment

Challenges of independent living

Participants mentioned various experienced and/or expected challenges related to living independently. More specifically, participants in various degrees mentioned how important it was for them to stay active, healthy, connected, mobile, independent and/or safe. The need to stay active could entail a number of activities, varying from being able to do housework, to being active in voluntary work. The need to stay connected included the need for social contact with others, but also the need to *"stay in touch with what is going on in the world"* (P14). For participants, wanting to remain independent not only implied being able to look after oneself, but also experiencing freedom to do what you want to do, and not feeling 'in debt' towards others such as family members, for example by asking them for help. Concerning the above-mentioned needs, a considerable amount of variation was noticed among participants. First, some participants displayed urgent concerns with regards to meeting experienced or expected challenges, while others mainly linked challenges to other older adults who were 'worse off' than they were. Second, while some participants spoke about various needs, other participants' discussions of needs were restricted to one or two needs that were central to them, and very much on the foreground (i.e., staying safe, healthy).

Use of technological and non-technological means

In order to meet their challenges in the domain of independent living, participants employed non-technological and/or technological means (i.e., technology products). Technological means used by participants included assistive devices (e.g., personal alarm buttons and electric lift chairs), home and personal care appliances (e.g., microwave ovens and electric toothbrushes), home automation devices (e.g., remote controlled power sockets and motorized rolling shutters), home fitness equipment (e.g., treadmills and exercise bikes), ICT devices (e.g., laptops and tablets), telephones (e.g., landline phones and feature phones), and transportation devices (e.g., cars and bicycles). These

technological means were used to various extents by participants. Some devices were part of participants' routines, while other devices were owned but used sub optimally, as was often the case with for example personal alarm buttons and fitness equipment. Additionally, the use of technological means regularly competed with the use of other technological means: *"I find my landline phone convenient… I do not want two… A mobile phone and a landline phone, that is too much for me"* (P3). Moreover, the use of technological means competed with the use of non-technological means, for example hiring a housekeeper instead of using a vacuum cleaner, or asking relatives to look something up online in order to avoid personally using a computer. The number and type of means available were dependent on each participant's specific context. In some cases, participants expressed to be forced to use a technological mean that they were not satisfied with, because they had no alternative.

Internal technology related schemas and attitudes

Analysis showed that through interacting with technological means, participants had formed internal technology related schemas and attitudes. Participants' technology related schemas contained three sets of beliefs. The first set of beliefs was concerned with the properties of technological means. For example, participants had favorable or unfavorable beliefs concerning the reliability, lifespan, power consumption, and costs of purchase and maintenance of technological means. The second set of beliefs entailed the perceived consequences of using a technological mean. These could involve consequences for the participant as well as consequences for others such as relatives. In many cases, participants perceived both positive and negative consequences of using technological means. For example, for a male participant living alone, using a microwave oven meant that he could remain independent because it allowed him to cook his own meals. At the same time, the fact that he could use a microwave also implicated that his children did not invite him as much for dinner as he would like to. Additionally, many participants did not want to start using assistive technology because they anticipated it would make them appear old or frail (a negative consequence). The third and last set of beliefs was concerned with participants' self-efficacy in using technological means. Participants frequently made references to their (in)ability to use certain types of devices (e.g., ICT devices), and anticipated using them would make them feel frustrated or stressed.

With regards to technology related attitudes, three types of attitudes could be

discerned: the participants' interest in technological means, the participants' perceived need for technological means, and the participants' willingness to invest in technological means. Concerning participants' interest in technological means, participants often spoke in general terms as if they were a technology-minded person: *"I have always loved everything that is technical"* (P9), or a 'non-technological' person. Whenever participants did not own or use a certain technology (e.g., smartphones or computers), they often stated that they did not perceive a need for it. In these cases, they regularly referred to alternative means that could meet their needs, or they stated that their needs or preferences were not in line with what that particular technology had to offer. The participants' willingness to invest in technological means entailed both the willingness to commit to a personal effort so that a device could be used, as well as the willingness to invest financially. Some participants were very willing to invest, while others pointed out that they only had a limited amount of energy and money, or were not motivated to try or learn a device: *"Frankly, I do not feel like putting in the effort"* (P29).

External influence of the social network

The social network included the participants' partners, their children, other relatives, and peers. These members of the social network provided participants with advice, and gave practical, financial and/or emotional support. Sometimes, participants mentioned that it was because of the social network that they owned a technological mean, not because they saw a need themselves *"When I got my first stroke, my children told me: mother you have to get a mobile phone! That's when my daughter gave me one"* (P6). Members of the social network also influenced participants because they were (co)users of technology. For example, participants saw the ways in which others used modern technology such as tablet computers and electric bicycles. Additionally, participants' use of communication devices was induced and maintained by relatives, who frequently e-mailed, texted or called participants.

External influence of the social organizations

Although less frequently mentioned, participants were also influenced by the actions of organizations; technology suppliers and stores, home care providers, and agencies that can provide financial compensation (i.e., insurance companies, municipalities). For example, participants frequently recollected that a special offer by a store triggered them to buy a device, and pointed out how important technical support was to them. Some participants

were concerned whether they would continue to be reimbursed for assistive devices that they had become accustomed to use (e.g., hearing aids). Certain policies of home care organizations also influenced the use of assistive technology, but not other types of technology. For example, some participants received information regarding available assistive devices, and were given the opportunity to try out a number of devices.

Physical environment

The last component of the status quo was the physical environment. Participants did not like devices that they considered too intrusive (i.e., disrupted the interior of their homes). Additionally, physical circumstances outside of the home such as inaccessible buildings and bad weather conditions sometimes interfered with using mobility aids and means of transport[3].

Decisive developments within the status quo

Participants owned an average of 27 devices at t_1. Over the course of the study (at t_2 and t_3), participants on average acquired a total of 3 devices. A total of 93 devices were acquired, of which 60 acquirements (65 percent) were discussed in semi-structured interviews with participants. Analysis showed that each time an acquirement had occurred, there were decisive developments that had taken place, which in turn triggered acquirement-enabling mechanisms. A total of 16 distinct developments within various components of the status quo could be identified (Table 3).

[3] For a more elaborative description of the (components of the) status quo, the reader is referred to [43].

Table 3. Decisive developments within components of the status quo

Component of the status quo	Decisive developments
Challenges of independent living	The older adult's needs change, causing an already owned technological mean to be less appropriate, or its use increasingly difficult
	The older adult anticipates a future increase in one or more needs
Use of technological and non-technological means	An already owned technological mean with expired warranty breaks down or wears out
	Maintenance costs of an already owned technological mean increase
External influence of the social network	People in the social network ask or advise the older adult to use a new technological mean
	People in the social network use a technological mean that the older adults does not have, and the older adult sees that they are very satisfied with it
	When visiting people in the social network, the older adult tries out a technological mean which he or she does not own
	People in the social network become dissatisfied with the use of a technological mean by the older adult
	A member of the social network acquires a new technological mean, leaving that member with a redundant device
External influence of organizations	A technology supplier or store makes an attractive offer
	Technology suppliers or stores no longer supply a technological mean, rendering it obsolete
	A home care organization distributes a technological mean to all of its clients
	A health professional advises a behavioral change
	A health professional advises the older adult to start using a technological mean
Physical environment	The older adult renovates the home
	The older adult moves house

In some acquirements, there was just one decisive development that took place. For example, the breaking down of a routinely used technological mean: *"The thing broke, so we had to buy a new one"* (P8). In other cases, multiple decisive developments took place, within multiple components of the status quo. For example, a male participant who had recently become single stated he wanted to have more contact with women (a change in his needs/challenges related to independent living). Additionally, he observed how people in his social network used their smartphones to chat and exchange photos with others: *"When I see others, I see how easy and enjoyable it is to do that"* (P24) (external influence of his social network). These two developments ultimately

led him to acquiring a smartphone.

In some cases, participants acquired various devices because of various decisive developments. For example, a female participant's decision to buy a new car (to meet her need of staying mobile), was induced by increased maintenance costs of her old car, and an attractive offer made by her car dealer. The same participant also bought a new laptop. In this case, her decision was induced by her grandchildren who wanted to be able to use Skype, and an increased need to experience new things in life.
In other cases, multiple acquirements were induced by a single decisive development, or a single combination of decisive developments. For example, a participant renovated his home, which led him and his wife to acquire several kitchen appliances. Other participants experienced a decrease in their health status, which led to the acquirement of multiple assistive devices.

Acquirement enabling mechanisms

When one or more of the aforementioned decisive developments occurred in the life of a participant, one or more acquirement enabling mechanisms were triggered. These acquirement-enabling mechanisms included motivations to acquire, and resources to acquire (Table 4).

Table 4. Motivations and resources to acquire

Type of mechanism	Subtypes	Description
Motivations to acquire	Personally needing a solution	The older adult realizes that there is a personal problem (challenge) that needs a solution
	Personally wanting to acquire	A technological mean becomes attractive to the older adult, because of favorable expectations and/or attractive pricing
	Envisioning oneself as a user	The older adult identifies with the users of a technological mean, in terms of personal characteristics and technology-related skills
Resources to acquire	Internal	The effort and money to acquire a technological mean are put in by the older adult, or by the older adult and his or her partner
	External	The effort and money to acquire a technological mean are put in by relatives and/or organizations
	Mixed	The effort and money to acquire a technological mean are put in by a combination of internal and external sources

Three types of acquirement enabling motivations could be discerned. First, participants could be motivated to acquire because decisive developments led them to realizing they had a personal problem that needed a solution. For example, a participant mentioned he realized he needed a mobility solution: *"At night, there are no buses, and on Sundays either, that means I am stuck here"* (P17). Second, participants could be motivated because decisive developments had triggered them into wanting to acquire a certain technology. This type of motivation was activated when a participant became attracted to a technology product because he or she had positive expectations of using it and/or because of attractive pricing of the product: *"It was marked down, a special offer. I said: 'This is worthwhile'"*(P33). The third type of motivation entailed participants envisioning themselves as future users of a technological mean. This implicated that the participant saw him or herself as eligible to be a user of a technology, and thus part of its group of users. This also meant that the older adult no longer considered him or herself superior to typical users ('only old and frail people use that'), or inferior to typical users ('that is something for people who are younger and smarter than me').

Looking at the resources needed to acquire devices, two types of resources were necessary: an investment of effort to acquire, and an investment of money to acquire. In many cases, the participants themselves, either with or without their partners, put in effort and money. However, participants had a limited amount of both of these resources at their disposal: *"I have had to learn: save money first, then shop"* (P20). Overall, participants appeared selective when it came to investing effort or energy in activities, including purchasing technology.

In other cases, the resources to acquire were provided by external sources, predominantly relatives or care organizations. This implicated that, in these cases, participants themselves did not have to invest effort or money in acquiring a technological mean. Typically, when resources were provided externally, no motivations to acquire were triggered in the older adult. For example, a participant was provided with an assistive device by a health care organization without ever considering it before: *"I never would have bought it myself"* (P6). In a minority of the cases, participants themselves set the external provision of resources in motion. For example, a participant mentioned to her daughter that she was interested in having a smartphone. Subsequently, her daughter selected and ordered a smartphone for her online, without further consulting the participant.

In other instances, the provision of resources was mixed, meaning that effort

and money were put in by internal and external sources combined. In these cases, there was a dialogue and/or cooperation between the participant and external sources, and/or an implicit or explicit division of tasks. For example, a participant and her daughter first discussed how and why the participant used her mobile phone infrequently, and subsequently went out and bought a senior phone together. In this case, the participant invested effort and money, and the participant's daughter invested effort. Cases where an acquirement was partly reimbursed by for example a municipality are also considered to fall under the category of mixed provision of resources.

Number and types of acquirements by participants

Over the course of the study, the combination of the status quo, decisive developments within the status quo, and enabling mechanisms influenced various types of acquirements (Table 5).

Out of the 93 technological means that were acquired by participants, nearly 40 percent were substitutions, meaning a device was replaced by an identical device. In nearly 29 percent of the cases, acquirements entailed the addition of a technological mean of a familiar type (e.g., an additional kitchen appliance). The addition of a novel, unfamiliar type of technological mean (e.g., first time acquirement of an ICT-device), was less frequent (16 percent). This also applied to cases in which a technological mean was replaced by a more advanced or newer variant (e.g., replacement of a bicycle by an electric bicycle). These types of acquirements were labeled upgrades, and made up 15 percent of the acquirements.

Table 5. Types of acquirements

Acquirement type	Description	Occurrences: n (%)
Substitution	Replacement of a technological mean, by an identical technological mean	37 (39.8)
Upgrade	Replacement of a technological mean, by a more advanced or newer variant	14 (15.1)
Familiar addition	Addition of a technological mean, of a type that is already owned and used	27 (29.0)
Novel addition	Addition of a technological mean, of a that not is not already owned and used	15 (16.1)
Total		93 (100)

The prevalence of these types of acquirements differed between participants (Table 6). Four out of the 33 participants did not acquire any technological means

during the study. Of the participants that did acquire technological means, three of them only acquired one device, all substitutions. Seven participants acquired one or two devices (upgrades and/or familiar additions), and seven other participants acquired three to five devices (a mix of three or four types of acquirement). Furthermore, two participants acquired seven to nine devices over the course of the study (either substitutions or familiar additions). In addition, there were ten participants who only acquired technological means in a single time period, either between the first and second home visit ($t_1 - t_2$), or between the second and third home visit ($t_2 - t_3$). Five of these participants acquired two devices, and five acquired four to six devices.

Table 6. Prevalence of acquirements per participant: number and types of acquirement

	Number of participants (%)	Number of acquirements	Type(s) of acquirement
Participants who did not acquire any technological means during the study	4 (12.1)	0	N/A
Participants who acquired technological means between t_1 and t_2, and between t_2 and t_3	3 (9.1)	1	Substitutions
	7 (21.2)	1 or 2	Upgrades and/or familiar additions
	7 (21.2)	3 to 5	Mix of 3 to 4 types
	2 (6.1)	7 to 9	Substitutions and familiar additions
Participants who acquired technological means between t_1 and t_2, or between t_2 and t_3	5 (15.1)	2	Mix of 2 to 3 types
	5 (15.1)	4 to 6	Mix of 2 to 3 types
Total	33 (100)	-	-

Moderating factors affecting number and types of acquirements by participants

Comparison between participants' acquirements over the course of the study led to the discovery of moderating factors, which influenced the number and types of acquirements by participants.

First, there were personal dispositions that came into play. Some participants were more impulsive than others. This was reflected in the time it took them to make purchase decisions. Furthermore, participants buying few technologies referred to themselves as being economical: *"That is what we are used to: how much does it cost? Isn't there a cheaper way? That is in our system, being economical"* (P32). Additionally, some participants were more willing to try out new things than others. For example, a participant who just bought herself an iPhone: *"An open-minded person. I want to participate in society. I*

do not have to be at the forefront... but I want to experience it" (P14). Lastly, participants differed with regards to how willing they were to ask people in their social network for help in buying technological means. This could lead to the postponement of purchases.

Second, there were situational conditions that influenced the number and types of acquirements by participants. Looking at the role of technology suppliers and stores, participants were more likely to purchase technological means themselves when there was a familiar store nearby that they could go to themselves. Offering home delivery was also mentioned as being important by participants. In some cases, participants found themselves in a buying spree: *"One thing led to another. Beforehand I was not thinking 'let's spend some money'"* (P14). This occurred for example when participants were renovating their home, and entered a period of spending. In the case of a buying spree, participants typically mentioned that there was a salesperson who understood their preferences and needs.

There were also conditions which limited or hindered the acquirement of technological means. For example, some participants mentioned they were swamped with choices, once they had decided that they wanted a certain type of device. In these cases, they did not know which model or brand to buy. When this occurred, several participants reverted to buying the same model as people in their social network. Too many options to choose from was also an important reason why participants did not buy devices online. In addition, the social network could limit or delay acquirements. For example, some participants disagreed with their partner on buying devices. Additionally, a participant reported that her children's assistance had its limits: *"Well, we went to one store. My son told me 'Mother, you should know that I do not have the time to visit all the stores with you'"* (P6). Furthermore, the participants' health status could limit the amount of energy they had to engage in acquirements, and it could make other situational conditions more critical (e.g., having a store nearby, availability of help by the social network).

Favorable and unfavorable consequences of acquirements

After participants acquired technological means, they had various experiences while using them, and new technological means could have various implications for their lives (i.e., their particular status quo's). For example, some participants were satisfied with their new device and used it routinely to satisfy their needs, while others hardly used a new device and did not express being happy with it. Analysis showed that favorable and unfavorable consequences of an

acquirement (i.e., experiences with the new device and implications for the status quo) were strongly linked to how that acquirement had originated (i.e., the combination of the status quo, decisive developments within the status quo, and enabling mechanisms). This can be illustrated by scenarios that involve both the origins and consequences of acquirements. A total of 36 distinct scenarios could be derived from the interviews. Scenarios included the specific status quo prior to acquirement, decisive developments within that status quo, triggered motivations and resources to acquire, the type of acquirement that occurred, experiences in using the newly acquired technological mean, and implications for the status quo. Moderating factors (i.e., personal dispositions and situational conditions) were not included in these scenarios. Table 7 shows four typical scenarios of technology acquirement with favorable consequences, and Table 8 shows four typical scenarios of technology acquirements with unfavorable consequences[4]. Each of these tables contains a scenario in which a device is substituted, a scenario in which a device is upgraded, the addition of a familiar type of device, and the addition of a novel type of device.

As can be seen in Table 7, a substitution (row #1) typically originated from a status quo in which a participant was routinely using a technological mean to satisfy his or her needs, without considering alternative means. In favorable scenarios such as the one displayed in Table 7, substitutions led to the restoration of the status quo prior to acquirement, meaning all was well (i.e., the same) again.
In the event of a typical upgrade (row #2), a participant originally used a technological mean routinely, but at the same time was surrounded by people who used a more advanced variant of that mean. In favorable upgrade scenarios, participants ended up with using a more advanced variant of a technological mean that met their needs. In a number of cases, this also resulted in participants gradually or suddenly ceasing to use the previous (older generation) technological mean.
Looking at the addition of a familiar type of device (row #3), this typically originated from a status quo in which one or more technological means of a similar type were already used to meet challenges. When an older adult added a familiar device, he or she had an additional technological mean at his or her disposal that could help meet challenges.

[4] Due to space constraints, it was decided to report eight prototypical scenarios. The other scenarios can be obtained by contacting the first author.

In contrast to a familiar addition, a novel addition (#row 4) typically originated from situations in which a challenge was not met by a technological (or non-technological) mean. This mostly occurred when health or safety challenges were not met. In favorable novel addition scenarios, acquirement led to the fulfilling of previously unmet needs. As an added benefit, participants had a positive experience with a new type of device. As such, their internal technology schemas were more profoundly affected, in comparison to the other less novel types of acquirements. For example, a female participant who acquired her first ICT-device, a tablet computer *"I am amazed, you know that? That I have learned how to operate it so quickly, and that I have grown accustomed to it. That I am doing it. I would like to see other nearly 79 year olds do this! Who would have thought?!"* (P30).

While 45 out of the 60 acquirements (75 percent) were successful in the sense that there were favorable consequences as mentioned above, there were also 15 acquirements (25 percent) that had unfavorable consequences. As can be seen in four typical unfavorable scenarios in Table 8, acquirement could for example lead to no improvement of the status quo, low satisfaction with the new device, and suboptimal use of the new device. In one scenario (Table 8, row #1), the newly acquired technological mean was simply not 'powerful' enough to mitigate the effect of a decisive development (cognitive decline).
In all other scenarios, analysis showed that unfavorable consequences of acquirements were predominantly related to the mechanisms that came into play (i.e., which motivations were triggered and how resources to acquire were provided). Two types of situations increased the chances of unfavorable consequences: (1) 'externally driven acquirements' with external or mixed provision of resources, and no or limited triggered motivations to acquire on the part of the older adult, and (2) 'purely desire-driven acquirements' with internal provision of resources, and personally wanting to acquire as the only motivation to acquire.
Examples of externally driven acquirements are provided in Table 8. In the first example (row #2), the social network provided a female participant with a smartphone, after her feature phone had broken down. However, the participant's needs and preferences did not seem to be taken into account in this process. As a result, the participant ended up with a phone she could not use. In the second example (row #3), a home care organization distributed personal alarms to all of their clients, without considering each client's personal circumstances. This resulted in the suboptimal use of this technological mean by three participants who were all clients of the same home care organization.

There was one other participant, who was also a client, who used the personal alarm as intended by the home care organization. This participant was already used to wearing a personal alarm button (i.e., the acquirement was a substitution), in contrast to the other participants.
Looking at desire-driven acquirements (e.g., row #4); these were acquirements in which participants themselves bought a device, solely because their personal want to acquire was triggered, usually by an attractive offer made by a store. In these cases, acquirements were not the result of an unfavorable status quo, or problems that arose as decisive developments. Participants bought a device because they wanted to, not because they really needed to. In these cases, participants felt 'fooled into it', and could feel guilty, such as a female participant who bought a laptop *"Yes, yes, I feel really guilty, for not having used the thing"* (P15). Some participants reported that they would think twice, the next time they would feel tempted to buy something.

Table 7. Scenarios of technology acquirement with favorable consequences

#	Origins of acquirement				Acquirement	Consequences of acquirement	
	Status quo prior to acquirement	Decisive developments	Motivations to acquire	Resour-ces to acquire	Type of acquirement	Short-term use and experiences	Implications for the status quo
1	A nutrition challenge is met by a routinely used technological mean (a coffee machine), and alternative means are not considered or used	The older adult moves house, and the technological mean does not fit in the interior of the new home	Personally needing a solution	Internal	Substitution of a coffee machine	Satisfaction and routine use	The status quo prior to acquirement is restored
2	A mobility challenge is met by a routinely used technological mean (a bike). People in the social network use a more advanced variant of the technological mean (e-bikes)	The technological mean breaks down, and its warranty is expired. People in the social network ask or advise the older adult to use a more advanced variant. A store makes an attractive offer	Personally needing a solution, personally wanting to acquire, envisioning oneself as a user	Internal	Upgrade of a bicycle to an electric bicycle	Satisfaction and routine use	The older adult has a more advanced technological mean at his or her disposal, and is using in to meet a challenge
3	One or more assistive devices are routinely used and are meeting a variety of health challenges	Health deteriorates rapidly. The older adult anticipates more health problems in the future	Personally needing a solution, Personally wanting to acquire	Internal	Addition of a familiar type of device; a mobility scooter	Satisfaction and routine use	The older adult has an additional technological mean to meet challenges
4	A health challenge (being overweight) is not met by a technological or non-technological mean	During a checkup, a health professional advises the older adult to start using a technological mean	Personally needing a solution	Mixed	Addition of a novel type of device; fitness equipment	Satisfaction and routine use	A previously unmet challenge is now met by a technological mean. Older adult has a positive experience with a new type of device

III

Table 8. Scenarios of technology acquirement with unfavorable consequences

#	Origins of acquirement				Acquirement	Consequences of acquirement	
	Status quo prior to acquirement	Decisive developments	Motivations to acquire	Resources to acquire	Type of acquirement	Short-term use and experiences	Implications for the status quo
1	A challenge (the need for social contact) is met by a routinely used technological mean (a feature phone1), and alternative means are not considered or used	Cognitive decline makes using the technological mean increasingly difficult. The social network becomes dissatisfied with the use of the mean and asks or advises the older adult to replace it	Personally needing a solution	Mixed	Substitution of a feature phone[1]	Low use and satisfaction	The acquirement cannot mitigate the effect of cognitive decline on the status quo
2	A challenge (the need for social contact) is met by a routinely used technological mean (a feature phone1). People in the social network use a more advanced variant of the technological mean	The technological mean breaks down, and its warranty is expired	-	External	Upgrade of a feature phone1 to a smartphone	Older adult cannot make phone calls, and advanced features are not used. Older adult needs help	Deterioration. Older adult has trouble using the technological mean, which is also not used to its full potential
3	A safety challenge is not met by a technological or non-technological mean	A home care organization distributes personal alarms to all of its clients. People in the social network ask or advise the older adult to use this technological mean	-	External	Addition of a novel type of device; assistive technology	Not satisfied with device. Older adult uses it only at night	Slight improvement. The new technological mean is not used to its full potential
4	One or more kitchen appliances are routinely used, and are meeting challenges related to independent living	A store makes an attractive offer	Personally wanting to acquire	Internal	Addition of a familiar type of device; a kitchen appliance	Not satisfied with device. Use decreases rapidly, then stops	No improvement. Older adult also has had a negative experience with acquiring a new device

[1] *A mobile phone that lacks the features of a smartphone such as the ability to download and install apps.*

Discussion

The current study sought to provide insight in the origins (i.e., contexts and mechanisms) and consequences (i.e., outcomes) of technology acquirement by independent-living seniors, by applying a realist approach [260,261]. Our findings can be summarized in a new conceptual model that is presented in Figure 1: The Cycle of Technology Acquirement by Independent-Living Seniors (C-TAILS). This model is both longitudinal and cyclic. It depicts how various types of technology acquirement originate from an independent-living senior's specific status quo and decisive developments within that status quo. Subsequently, the model shows how these decisive developments can trigger a number of acquirement enabling mechanisms, and how acquirement can be influenced by personal and situational moderating factors. Lastly, the model depicts the consequences (or implications) of technology acquirement, which are mediated by the seniors' experiences with the newly acquired technology. As such, the C-TAILS model depicts and integrates both the origins and consequences of technology acquirement by independent-living seniors. It provides an integrated perspective on why and how technological means are acquired, and why these may or may not prove to be appropriate and effective, considering an independent-living senior's needs and circumstances at a given point in time. Because of our focus on understanding seniors' technology acquirement in a natural setting, our study is inherently interdisciplinary [267]. Consequently, our findings and model touch upon and potentially impact several streams of research, including gerontological research, consumer research on buying behavior, and research on acceptance and adoption of technology. Looking more closely at our results, several observations can be made.

First, our results indicate that independent-living seniors' lives should not be considered static. Rather, independent-living seniors' lives can be characterized as a changeable system of related components (i.e., the status quo). An important characteristic of the status quo is the balance between seniors' experienced and/or expected challenges related to independent living, and the technological and non-technological means that they have at their disposal to meet these challenges. As such, our findings are in line with gerontological research on seniors' perspectives on how to age healthy at home [268], and the continuity theory of normal aging, which poses that seniors strive to preserve and maintain what they have [269]. Our findings are also in agreement with

one of the leading models of successful aging, the Selective Optimization with Compensation model (SOC-model) [270]. According to the SOC-model, people select life domains (needs) that are important to them, optimize (acquire) means and resources that facilitate success in these domains, and compensate for losses in these domains (for example by using alternative means) in order to adapt to changes and age successfully [270,271]. As in the SOC model, our participants varied to the extent that they were conscious of their needs, and acquired means and compensated for the loss of means in active or passive ways.

All in all, our model and the SOC model both highlight the importance of taking a broad perspective when it comes to understanding the acquirement and use of a technology by an independent-living senior. It is important to understand the senior's needs, but also how the technological mean relates to the other technological and non-technological means that the senior has at his or her disposal. A difference with the SOC-model is that our model also takes into account the multifaceted influence of the social network and organizations: these entities can influence the senior's opinion on technological means, they can provide technological means, and they can be seen as non-technological means that compete with technological means.

Second, our findings show that technology acquirements by independent-living seniors are the result of change(s). One or more decisive developments are vital for acquirement to occur, and these developments activate motivations and resources for acquirement. These findings are in contrast with existing technology acceptance models [40,47,48,57,235,236], that can be traced back to one seminal theory that originated from social and cognitive psychology: the theory of reasoned action [272]. As result, these models employ variance theory to predict an individual's intention to use a technology [273]. The perceived usefulness and ease of use of a technology are the two most important predictors within these models [40,47,48,57,235,236]. However, the aforementioned technology acceptance models do not take into account changes or developments over time [11,59]. Additionally, the dominance of these variance based models has led researchers to mainly focus on capturing the factors that influence technology use (the what), rather than capturing or understanding the processes that lead to technology use (the why and how) [42,152,273,274]. The mechanisms (motivations and resources) that we describe in our model of technology acquirement are similar to previous works on technology acceptance by older adults. These works acknowledge*Figure 1. 99* the essential role of perceived benefits and costs of technology, perceived

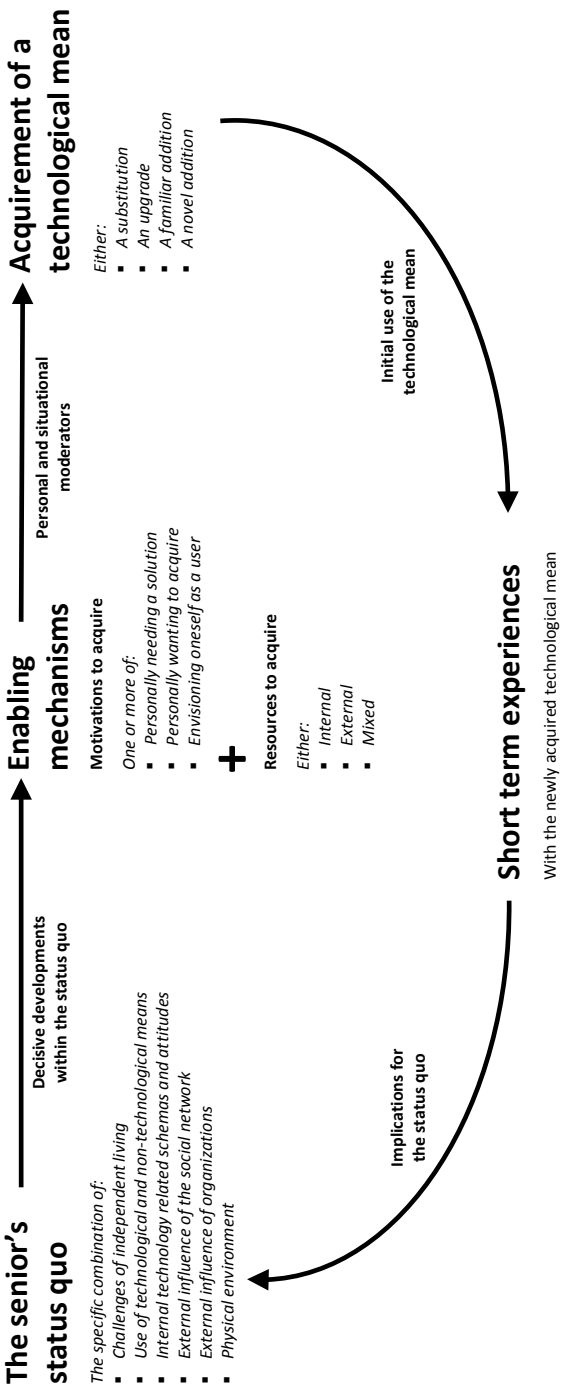

Figure 1. Cycle of Technology Acquirement by Independent-Living Seniors (the C-TAILS model)

need for technology, support by the social network and the degree to which a technology is in line with the older adult's self-concept [11,63,111,186,194]. What is different is that our model also describes the developments and context that lead to the triggering of these mechanisms. As such the current study can be seen as a response to generally unheeded calls for longitudinal research to better understand developments in the process of accepting technology [40–43]. By describing and incorporating influential developments (changes) as well as relevant context, we hope to contribute to the development of alternative theoretical perspectives, a path recently called for by prominent technology acceptance scholars [56,59,152]. More specifically, while perceived need and usefulness are frequently mentioned constructs in literature on technology use by older adults, we feel that there exists little understanding in the literature of what these concepts actually entail for older adults. Why do older adults perceive a technology as useful? And how do older adults develop a need for a technology? Our findings indicate that perceived need for a technology and usefulness of a technology are a function of the older adult's particular status quo and developments that occur within this status quo. As the current study is explorative, more research is needed to confirm these findings, and to further develop our understanding of the personal relevance of technologies to independent-living seniors.

Third, it is worthwhile to compare our findings to classical process models that describe stages of technology adoption [178] and consumer decision making [192]. According to Rogers [178], individuals who adopt innovations such as technologies pass through the stages of (a) becoming aware of an innovation, (b) forming an attitude toward the innovation, (c) engaging in activities that lead to a decision to adopt or reject the innovation, (d) putting the innovation into use, and (e) seeking confirmation of the decision to adopt. While frequently cited, we are not aware of any empirical studies that have researched these adoption stages among older adults. It is important to note that according to Rogers an innovation is *"an idea, practice or object that is perceived as new by an individual"* [178]. In the case of the current study, this mainly applies to the acquirements that we have labeled 'novel additions', and to some extent to acquirements that we have labeled 'upgrades'. Nearly half of our sample did not experience these two types of acquirements. Additionally, looking at our entire sample, these types of acquirements occurred considerably less frequent than 'substitutions' and 'familiar additions'. Previous research suggests that this may be because deciding on buying novel or more advanced types of products can be difficult for all consumers, and for older

consumers in particular [35,275–280]. Over the years, older adults have gained extensive experience in buying and using certain types of technology (e.g., home appliances, means of transportation), while unfamiliar, novel types of technology (e.g., ICT devices, assistive technology) are often more difficult and stressful to buy and use [35,281]. Additionally, it has been argued that older adults are more prone to use heuristic/intuitive decision making, which can be characterized as experiential, associative and automatic [35,282]. This type of decision-making requires limited processing resources, as older adults are able to rely on their internal schemas regarding products, and their affect towards products. As such, this type of decision making seems congruent with buying familiar products [35,282]. In contrast, buying unfamiliar products may require systematic/elaborative decision making, which is more analytical and resource consuming. This type of decision making involves consciously going through the classic stages of consumer decision making: problem recognition, information search, alternative evaluation, purchase decision, and post-purchase evaluation [35,282]. The abovementioned research may explain why the classical stages of technology adoption and consumer decision-making cannot readily be fitted to our data; the majority of the technology acquirements by participants are not very novel, and they regularly appear not to be deliberative. For example, many participants 'automatically' acquired a similar device because the old device broke down. Additionally, the resources to acquire devices could be provided by older adults themselves, by relatives/organizations, or by a combination of both. This is different from the classical stages of technology adoption and consumer decision-making that are mainly focused on self-adoption and self-buying. Our findings show that in some situations seniors act as independent consumers who make their own choices, while in other situations they are in a more passive role and are provided with means by their environment, and in yet other situations they work together with their environment to acquire means.

Returning to the difference between more familiar and more novel types of acquirement, the current study shows that these acquirement types originate from different starting points (i.e. status quo's). Substitutions and familiar additions originate from situations in which older adults use one or more similar devices that are already satisfying their needs. Upgrades mainly occur in situations in which older adults are surrounded by people who use more advanced variants of an already owned and used device. Interestingly, novel additions are the only type of acquirement that originate from unmet needs. This is in line with a suggestion made by Lunsford and Burnett: *"If the product can meet an otherwise unmet need, the elderly consumer may be able to*

overcome the risk of buying an unknown good" [277].

Fourth and last, it seems that the motto 'the customer is always right' very much applies to older adults. In line with previous research [283], the vast majority of the technology acquirements by participants were successful, in the sense that they used them, were satisfied with them and they fulfilled their needs. In the literature and by the general public, older adults are often viewed as 'critical consumers' [244,247]. Based on our findings, one could argue that older adults are rightfully critical; their technology acquirements are only unsuccessful when they are 'externally driven' or 'purely desire-driven'. In both situations, our participants felt 'tricked into' acquiring a device. Other research suggests that older consumers' lifetime experience with persuasion attempts may make them relatively resistant to deceptive marketing appeals [284].

Limitations and suggestions for research

With regards to our data collection and our interactions with participants, several limitations need to be discussed. First, our decision to only interview participants on devices that could support activities of daily living, personal health or safety, mobility, communication, and physical activity may have induced a bias. It is important to note that older adults have more needs than those described in the current study, such as the need to be creative, and the need for personal development. Additionally, older adults also buy nonessential goods such as leisure, entertainment, personal care, and luxury goods [44].

Second, our interview data may have been affected by recall bias since we asked our participants to look back in time in order to construct their acquirements of technology. More specifically, research suggests that older adults' memory for information tends to skew more positive than that of younger adults [285], causing them to be more satisfied about products than younger consumers across a number of product domains [283]. We have attempted to limit recall bias by only including participants with normal cognitive functioning, by specifically asking participants for positive and negative experiences, and by discussing information put forward by participants that differed from previous interviews with them. The latter occurred rarely, participants seemed to have formed internal storylines of why they acquired technology that remained consistent over the course of the study.

Third, as the study progressed we noticed that participants increasingly

considered us trustworthy and opened up more, which facilitated our data collection. On one occasion, a participant disclosed that her acquirement of technology was influenced by an interview. She noted that the interview had caused her to reflect on her technology use, and that this was one of the reasons for her to acquire a number of technologies. According to her, this was due to the topics we addressed, and not a consequence of our style of interviewing. We subsequently asked all other participants whether they felt we were influencing their acquirement and use of technology. All other participants responded that this was not the case.

Looking at our model and findings, there are several areas that could benefit from further research. First, our design focused on exploring why independent-living seniors acquired devices, and not on why they did not. Further research is necessary to understand the context and mechanisms of acquirement processes that are not started, or are aborted. This type of research may also lead to insights on mechanisms that impede acquirement, and mechanisms that limit the enabling mechanisms that we have described.

Second, the current study solely describes older adults' perceptions of their status quo and developments and mechanisms that led to acquirement. Our model could be expanded by also integrating the perspectives of older adults' spouses and relatives, as well as care organizations they interact with. It would be interesting to integrate their perspectives on the older adults' status quo, their views on what mechanisms influence acquirement, and their motivations for providing resources for acquirement. This also would entail collecting more information on the size and nature of older adults' social networks. As others have pointed out, successful aging in place is socially and collaboratively accomplished [222,286].

Third, our model could benefit from better specifying the role of affect in technology acquirement processes. While emotions were part of the stories told by participants, we feel that using qualitative methods may not be the best way to capture their precise role. Quantitative research, for example by employing scales developed by Bagozzi [287], may shed light on emotional involvement in the adoption process, by measuring anticipated and anticipatory emotions. Based on our findings, we believe that understanding the role of emotions may be particularly important in novel (unfamiliar) types of acquirement.

Finally, our participants' views and contexts, as well as their acquirements of technology are likely to be influenced by cultural aspects and the organization of the local and national health care system. Studies in other regions and countries are necessary to determine if our results can be generalized.

Implications for practice

Independent-living seniors are not only different from each other; they are also different from themselves at different times. This poses problems for those that seek to deploy or implement technologies that aim to support aging in place. It is challenging to present independent-living older adults with relevant and timely offerings.

In dealing with the aforementioned issues, the C-TAILS model can be used to facilitate the deployment and allocation of already existing technological solutions for aging in place. In this pursuit, the C-TAILS model can be used for assessing an older individual's specific status quo, to understand his or her specific needs and circumstances, in order to determine if technologies in line with these needs would be a welcome addition. Ideally, organizations would over time learn what decisive developments and personal motivations influence their independent-living clients' technology readiness, and organize the allocation of technological solutions to clients accordingly. Using this strategy, the number of ineffective 'externally driven' technology acquirements can be reduced, and older adults can be provided with meaningful and welcome technological means to help them age in place.

Additionally, the C-TAILS model can be of benefit to practice by informing more effective forms of market segmentation, market-research and product design that are more in line with independent-living seniors' needs and perceptions. Looking at market segmentation, others have noted that dividing a heterogeneous population such as independent-living seniors in subgroups is problematic, even more so if traditional dimensions such as demographics and personal characteristics are used and treated as being static [247,288–291]. As Dickson noted with regards to segmentation "A demand results from the interaction of a person with his or her environment, a segmentation perspective that includes both the person and the situation is needed to explain demand" [291]. In our opinion, and unlike traditional segmentation models, this requires the assignment of more than one segment to each unique older consumer, as the circumstances of that consumer can change. The C-TAILS model can be used to explore and identify these consumer-circumstances segments. This can be done by employing the C-TAILS model in ex ante market research. Ex ante market research frequently employs qualitative methods and aims to shed light on the motivating conditions that ultimately determine the kinds of benefits and attributes that customers will value [292]. Likewise, the C-TAILS model can be used within a contextual design process of technological solutions for independent-living seniors, as the core of this design philosophy is to understand users fundamental intents, desires, and drivers [293].

Conclusion

Technology acquirement by independent-living seniors may be best characterized as a heterogeneous process with many different origins, pathways and consequences. Furthermore, technologies that are acquired in ways that are not congruent with seniors' personal needs and circumstances run a higher risk of proving to be ineffective or inappropriate. Yet, these needs and circumstances are subject to change, and the C-TAILS model can be employed to better understand contexts and mechanisms that come into play.

8

Changes and stability in the use of technologies by independent-living seniors: a dynamical framework

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Submitted

Abstract

Background and Objectives If technologies are to support aging in place, then it is important to develop fundamental knowledge on what causes stability and changes in the use of technologies by seniors. However, longitudinal studies on the use of technologies that have been accepted into the home (i.e., post implementation acceptance) are very scarce. To better understand changes and stability in the use of technologies by independent-living seniors, a dynamical systems theory approach was employed. **Design and Methods** A longitudinal qualitative field study was conducted involving home visits to 33 community-dwelling seniors in the Netherlands, on three occasions (2012-2014). Interviews were held on reasons for stable, increased, declined and stopped use of technologies. Thematic analysis was employed, using constant case comparison to better understand dynamics and interplay between factors. **Results** A core of six interrelated factors was closely linked to the frequency of technology use: emotional attachment, need compatibility, cues to use, proficiency to use, input of resources, and support. Additionally, disruptive forces (e.g., social influences, competition with alternative means, changes of personal needs) could induce change by affecting these six factors. Furthermore, technology use was in some cases more resilient to disruption than in other cases. Findings were accumulated in a new framework: Dynamics In Technology Use by Seniors (DITUS). **Discussion and Implications** Similar to aging, the use of technologies by older people is complex, dynamic and personal. Periods of stability and change both occur naturally. The DITUS framework can aid in understanding stability and instability of use.

Introduction

Increasingly, technology is viewed as a potential resource for facilitating or improving aging in place [181,294]. Technologies for aging in place are typically designed to support or enhance activities of daily living, personal health or safety, mobility, communication, and physical activity [11]. They are also referred to as gerontechnology, ambient assisted living technology, smart home technology, or eHealth. Specific examples include vital signs monitoring and fall detection devices, mobile phones specifically designed for seniors, and medication reminders [11,12]. Additionally, older adults can take benefit of generally available consumer appliances and devices that play a role in staying independent, active and healthy (e.g., fitness equipment to stay physically active, home appliances for activities of daily living, and information and communication technologies to support social contact) [14,43,187]. Yet, technologies can only provide benefits if they are used by older adults. In this respect, it is important to acknowledge that successful aging in place is essentially a matter of adapting to aging and environmental changes [114,295,296]. If technologies are to play a role in independent living, it important to develop fundamental knowledge on what causes stability and changes in the use of technologies over time. Preferably, the use of supporting technology is sustainable.

Within the scientific literature, the emphasis very much lies on why independent-living older adults would start to use technology in the first place (i.e., pre-implementation acceptance) [11]. Studies on (fluctuations of) the use of technologies that have been accepted into the home (i.e., post-implementation acceptance) are very scarce. In particular, longitudinal studies are lacking [11,25]. Additionally, the majority of studies only focus on the acceptance of one (type of) technology, thereby neglecting the fact that the use of a particular technology may very well be dependent on the availability and use of technological and non-technological alternatives [43,297]. Furthermore, many more factors potentially could influence why older adults would continue or change the use of technologies in the home. These include the occurrence of life events, age-related decline, changes in personal goal orientation, and various types of social influences [26,62,106,195]. The aforementioned factors are likely to be interrelated, adding to the complexity. In aiming to understand changes and stability in frequency of use of technologies over time, Dynamical Systems Theory (DST) can be of use [298]. DST stems from

the fields of mathematics and physical sciences and is increasingly applied in other fields including biology and psychology [298,299]. It has generated interest and excitement as a series of principles and tools for studying change and equilibria (i.e., states of stability) [300,301]. In DST, values of variables at one time are modeled as functions of those same variables at earlier times. In contrast to linear (non-dynamical) models, variables can serve as both dependent and independent variables at the same time. This is why feedback loops play an important role in dynamical system models [300]. Together, one or more feedback loops of variables form a 'system' of interacting components. The current state of a system can be challenged by external disturbances and internal fluctuations. Ultimately, these disturbances and fluctuations can lead to breaking points, causing the system to shift to an alternative state [302]. DST can be used to simulate or test mathematical equations of change, or it can be used as a metaphor, whereby concepts are applied qualitatively without the use of mathematical relationships [298,303]. In the current qualitative study, DST is used as a theoretical lens while addressing the following research questions: (1) Why does the frequency of use of technology by independent-living older adults remain stable over time; and (2) What drives changes in the frequency of use of technology by independent-living older adults. As suggested by others, we will illustrate our findings by using graphical representations of DST concepts [299,300].

Design and methods

Design

The current study was set up as a prospective longitudinal qualitative field study [257], involving home visits to independent-living older adults on three occasions (t_1, t_2, and t_3; 2012-2014).

Sampling

After receiving approval for the study from the Ethics Review Board of the Tilburg School of Social and Behavioral Sciences, a purposive sample of independent-living older adults with different health statuses, living arrangements, and levels of technology experience was recruited. Participants were recruited in a medium-sized city in the Netherlands via two home care providers, a senior volunteer organization, a local tablet computer pilot project, a local shopping center, and word of mouth contacts. Criteria for the inclusion of participants were:

(1) independently living at home, (2) aged 70 years or older, (3) Dutch nationality, and (4) no cognitive impairment as measured by the Mini-Mental State Examination (MMSE) [190] using a score of 24 as cutoff [229]. Potential participants were given an information letter and were telephoned to schedule the first home visits if they were interested in participating. Of the 72 individuals approached, 53 agreed to participate (N = 53, t_1). One participant was included per household. Subsequently 18 and 2 participants dropped out (N = 35, t_2; N = 33, t_3). Reasons for drop out were: not interested in continuing (n=5), deceased (n=4), somatic health problems (n=4), cognitive impairment (n=2), too busy providing informal care for their partner (n=2), no longer living independently (n=2), and lost contact (n=1). For the study reported here, only individuals who participated in t_1, t_2 and t_3 were included (N = 33).

Data collection

Pairs of researchers (SP, MN, SA, CvdV, and MR) performed home visits, and informed consent was acquired at the start of each first visit. At the end of the first visit, participants were offered a magazine subscription of their choice. Prior to subsequent visits, participants were sent a letter containing information on the research project's progress and called to schedule a visit at their convenience.

At t_1 (September – December 2012) the aim was to gain an initial understanding of participants' lives, their perceptions and attitudes towards technologies, and their use of technologies. Three types of data collection were performed: (1) background information on educational level, civil status, living arrangement, level of formal and informal care, chronic conditions, subjective health status, occurrence of life events in the last 12 months, frailty as measured by the Tilburg Frailty Indicator (TFI) [189], and cognitive functioning as measured by the MMSE [190]. TFI scores could range between 1 and 15, MMSE scores could range between 0 and 30; (2) an inventory of technologies in the home. For this purpose, participants and researchers jointly made a tour through the home. Technologies were included if they required electric power in order to function, were intended to be used in or around the home, and could support activities of daily living, personal health or safety, mobility, communication, and physical activity. Frequencies of use of these technologies were recorded using the categories: (nearly) daily; at least once a week; at least once a month; less than once a month, and stopped using, or never used; (3) semi-structured interviews in which participants were interviewed on reasons for the frequency

of use of technologies. A topic list was adjusted as data collection progressed.

At t_2 (May – July 2013) and t_3 (March – June 2014) data collection was aimed at understanding why participants' use of technologies remained stable or changed since t_1. First, the same type of background information on participants as in t_1 was gathered, and the inventory of technologies in the home was updated. Second, semi-structured interviews were conducted on at least one technology of which the frequency of use was identical to the previous visit, at least one technology of which use had increased, and at least one technology of which use had decreased or stopped entirely. During the interviews, we took into account background information that was gathered on each participant and relevant themes which had emerged in previous interviews. We made sure that at least one of the two visiting researchers had visited the participant before. The topic list used was further evolved as data collection progressed. All of the interviews were audiotaped and transcribed verbatim.

Analysis

Thematic analysis [258] was employed by SP, KL, MN, SA, CvdV, and MR. Analysis took place during and between all three waves of the data collection and was supported by the use of qualitative data analysis software (Atlas.ti). We studied transcripts and attached inductive codes to quotations relevant to the research questions. All t_1 transcripts, two-thirds of the t_2 transcripts, and one-third of the t_3 transcripts were first coded independently by two different researchers. The two researchers then discussed their analyses and produced a single coded version of each transcript. Coding was detailed; often multiple codes representing different factors influencing technology use were attached to quotations. Periodically, these coded transcripts were combined into one Atlas.ti file by SP. This file was used in group sessions in which new codes were discussed, and overarching themes were formed. In order to better understand the dynamics and interplay between factors and themes (codes) over time, SP then applied constant comparison [265], systematically comparing the use of various types of technology by each participant, and between participants. In this iterative process, insights and findings were discussed with KL, HV, and EW on a regular basis.

Member checking

To promote descriptive and interpretative validity [266], a written summary of each interview was sent to participants by mail shortly after each interview

took place. On one occasion, a participant felt she was misinterpreted during an interview. This was discussed with the participant, and taken into account during data analysis. Furthermore, to promote theoretical validity [266], additional home visits were made to participants, in which the sole purpose was to share our interpretations of the data (after t_3, in June and July 2015). With participants, we discussed findings that were specific to them, including usage patterns and changes we observed during the study. Out of the 33 participants, 25 participated in this final member check. Reasons for not participating were: personal health problems (n=3), deceased (n=3), and lost contact (n=2). Participants recognized themselves very well in our descriptions of them and their use of technologies.

Results

Sample

The sample consisted of 33 participants. Nearly 61 percent of the participants was female. The average age of participants was 76.1 ± 3.9 at t_1, and 77.5 ± 3.9 at t_3. The majority of the participants had attainted secondary education (61 percent), while 27 percent attainted no or only primary education, and 12 percent attained a form of higher education. During the study, the proportion of participants that lived alone increased from nearly 64 percent at t_1 to 67 percent at t_2 and t_3. A proportion of participants received home care: at t_1 this was 58 percent, at t_2 nearly 67 percent, and at t_3 nearly 64 percent. Looking at subjective health; close to 70 percent of the participants considered their health good, very good, or excellent at t_1 and t_2. At t_3, this was 61 percent. Participants' frailty (TFI) score, was lowest at t_2 (3.8 ±.4) and highest at t_3 (4.6 ± 2.6)[5]. The cognitive functioning (MMSE) score was lowest at t_1 (28.1± 1.5) and highest at t_2 (28.5 ± 1.5)[6].

Stable use of technologies

Analysis of participants' technology use showed that the frequency of use of a technology was directly influenced by a combination of six factors. Together, these factors formed a system of interrelated components that explained why participants maintained a frequent or less frequent use of certain technologies over time. Two examples of how this system can operate are displayed

[5] As suggested by Gobbens et al. (2010), a Tilburg Frailty Indicator (TFI) score of 5 was used as the cut-off point for frailty

[6] As suggested by Kempen, Brilman and Ormel (1995), a Mini-Mental State Examination (MMSE) score of 24 was used as the cut-off point for cognitive impairment.

in Figures 1 and 2. Figure 1 explains Elisabeth's[7] frequent (daily) use of her computer, and Figure 2 explains Paul's infrequent (monthly) use of his mobile phone. As can be seen in both figures, frequency of use was influenced by four feedback loops (with emotional attachment, need compatibility, cues to use, and proficiency to use), and two additional factors (input of resources and support). In both cases use was stable, meaning the same frequency of use was reported at t_1, t_2 and t_3.

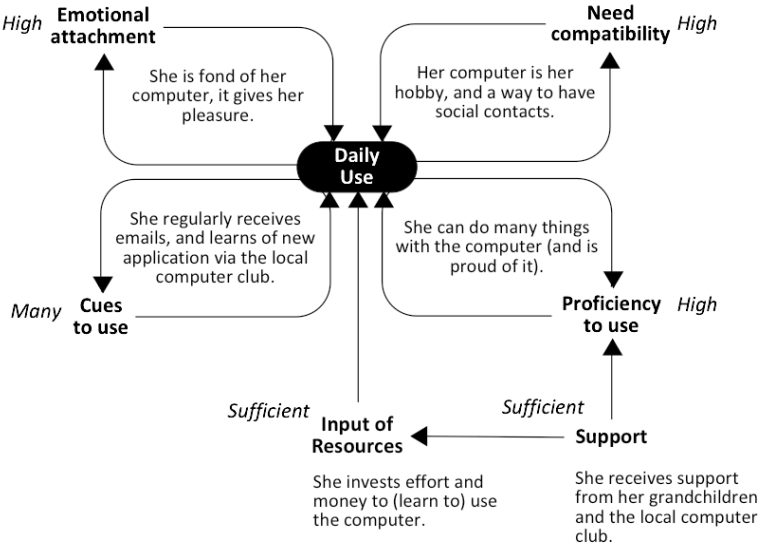

Figure 1. Reasons for Elisabeth's stable and frequent use of her computer

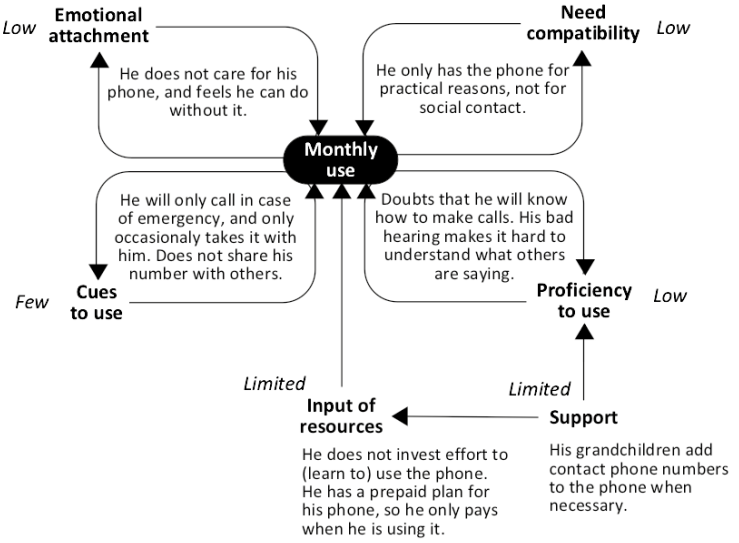

Figure 2. Reasons for Paul's stable and infrequent use of his mobile phone

[7] All names in this paper are fictive to protect the identity of participants.

In the case of Elisabeth's frequent use of her computer (Figure 1), interview data showed that she used her computer because she was emotionally attached to it, and that using the computer cultivated her emotional attachment (hence the feedback loop). As she explained it: *"You can do all sorts of things with it, my music is on it, the photos I take are on it. It's a lot of fun"* (P20). And: *"I feel like I could be getting addicted to it" (P20). Elisabeth also used her computer because it was compatible with her needs, and using the computer reaffirmed this (the second feedback loop): "I: What do you like most about it? P: Just the fact that I am able to send messages and have social contacts. It's just great! I: You strike me as a social person". P: Yes I definitely am"* (P20). Additionally, Elisabeth experienced certain cues that led her to using the computer. In general, we found that in participants' lives cues to use could entail specific situations, routines and places. In Elisabeth's case, she regularly received e-mails because she used her computer to send e-mails (the third feedback loop). Additionally, Elisabeth stated that she used her computer because she learned of new applications at the local computer club, and she went to the computer club because she was a user of the computer. Using the computer also made her feel very proficient, and her proficiency enabled her to make use of the computer (the fourth and last feedback loop): *"It's good for my self-esteem, the fact that I am able to do it"* (P20). In Elisabeth's case, there were sufficient resources (i.e., effort and money) to be able to use the computer. These resources were invested directly by herself, and indirectly by external sources of support. As external sources of support she mentioned members of the local computer club and her grandchildren, who also helped her when needed.

In contrast, looking at Paul's infrequent use of his mobile phone (Figure 2), data showed that circumstances for technology use were far less favorable. In contrast to Elisabeth's fondness of her computer, Paul did not care for his mobile phone (low emotional attachment). Additionally, need compatibility was low, since the mobile phone was only in line with one need: *"I only have it for when I go driving, in case the car breaks down"* (P12). This was different from Elisabeth's case, where the computer was compatible with more of her needs. In Paul's case, there were also few cues to use, and proficiency to use was low. Lastly, input of resources and external support were both limited. It is important to note that Paul did maintain a certain (infrequent) level of use. However, as a result of him frequently not taking his mobile phone with him, he was not able to call for help when he experienced a fall outside his home. While he regretted not taking it with him, this incident did not affect Pauls' mobile phone use.

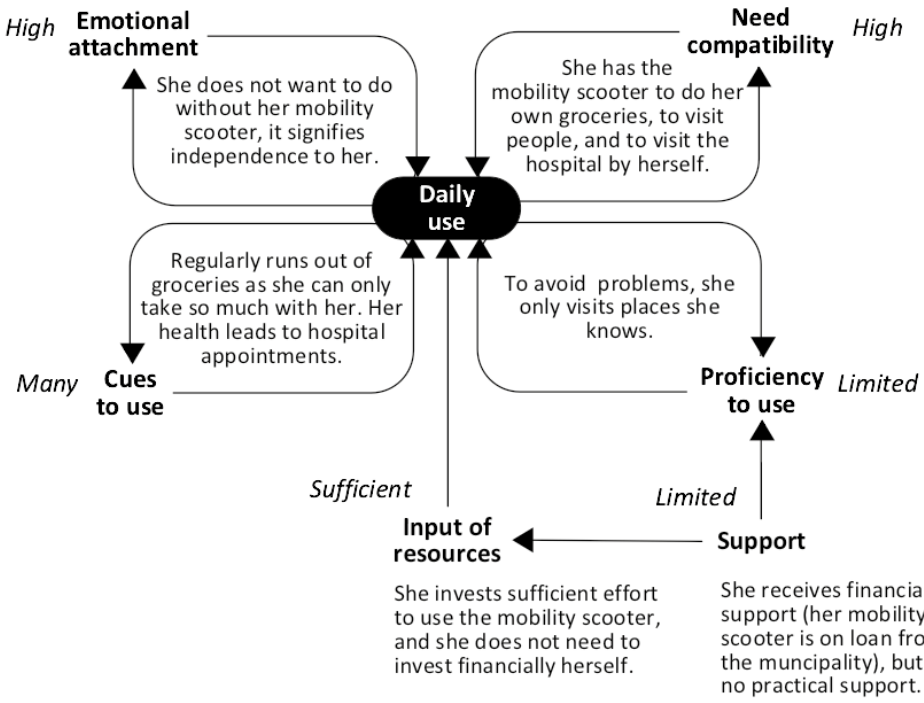

Figure 3. Reasons for Linda's stable and frequent use of her mobility scooter

Elisabeth's and Paul's cases represent two extremes, featuring only favorable or only unfavorable factors influencing technology use. In other less extreme cases, some factors were favorable for technology use, while others were not. An example is displayed in Figure 3. As seen in this example, Linda used her mobility scooter daily, and need compatibility and emotional attachment were high. There were also many cues to use, and sufficient input of resources. However, Linda's proficiency to use the mobility scooter was limited as she only felt confident in using the mobility scooter to visit places she already knew. *"I need to know beforehand where I can go, and how to get here. I need to know that"* (P28). As a result, she was dependent on a local bus service for people with disabilities, if she wanted to visit a place that was new to her: *"Then I need to make use of the special bus service… it requires you to make an advanced reservation… when you want to go back home, you stand there and wait"* (P28).

Shifts to other states of use

Longitudinal analysis showed that the use of technologies by participants was subject to various disruptive forces (Figure 4). These forces could influence the six interrelated factors that were described in the previous paragraph. As a consequence of these dynamics, the use of a technology at a certain point in time (i.e., the current use state), could change to a state of increased use or decreased use. Dynamics between disruptive forces and the system of the six interrelated factors could also lead to a situation in which a participant stopped using a technology (i.e., the abandonment state). Additionally, it appeared that a certain amount of disruption had to take place before use actually changed to a different state. In other words, there were breaking points. Moreover, the use of a technology was in some cases more resilient to disruption than in other cases. This depended on the robustness of the system of the six interrelated factors (i.e., the level of emotional attachment, the amount of cues to use etcetera), and on how quickly and effectively participants and external sources of support responded to disruption. Personal characteristics of participants played a role here (i.e., active vs. passive coping style, willingness to change, willingness to ask for support).

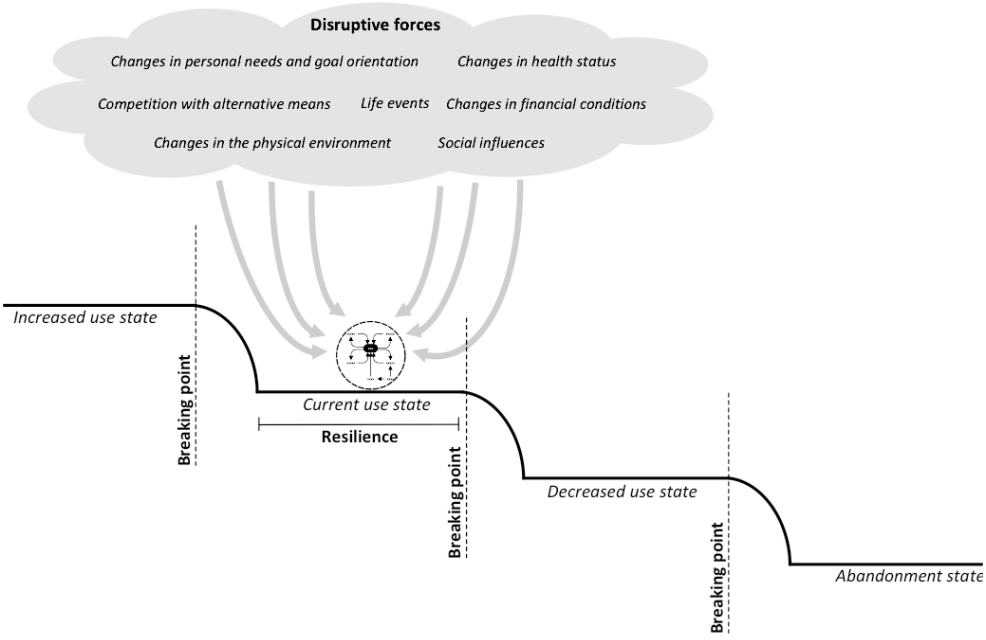

Figure 4. Shifts to other states of use as a result of disruptive forces

For example, Figure 5 displays Sheila's gradually decreased use of her iron. When we visited Sheila at t_1 she used her iron every week. At that time, she rather enjoyed ironing and also ironed clothes of her daughter. At t_2, things had changed considerably. She had experienced a fall, and her arthrosis bothered her more than before: *"I cannot stand so long on my legs anymore, particularly my left leg"* (P13). These changes in her health status had several effects: she could not iron as much a before (lower proficiency to use, and less investment of resources), she did not enjoy ironing as much as before (lower emotional attachment), and she ironed in less situations (less cues to use). Additionally, Sheila still wanted to keep her clothes tidy but she could not use her iron to meet this need anymore (lower need compatibility). Instead, she used alternatives to ironing, such as hanging and folding her clothes. This also occurred in cases which involved other participants: decreased use of a technology could go together with increased use of alternatives to that technology. Sheila used alternative means because she was forced to, because she could not iron anymore. In contrast, we also saw cases in which participants voluntary decided to make more use of an alternative mean to meet their needs. In Sheila's case, the result of the abovementioned developments was a notable decline in frequency of use at t_2. Frequency of use continued to decline, and at t_3 she only used her iron incidentally. At this stage, Sheila still had health issues, although her legs had not gotten worse. It seemed that Sheila had come to terms with hardly using the iron *"I am at a point where I do not care anymore about it… No, I just don't feel like using it"* (P13). We saw this more often among participants; it seemed like there was a point in which they had gotten used to the new state of affairs. This also occurred in some cases in which the use of a technology was temporarily decreased due to a life event (e.g., a partner having a serious illness) or less dramatic events such as getting the flu or temporarily receiving less support. After a while, need compatibility, usage cues and emotional attachment would decline, as participants realized they could very well live with using the technology less. If use was decreased long enough, this could ultimately lead to stopped use (i.e., abandonment state). In particular, this was the case when use had become so infrequent that proficiency became severely impeded, as one participant puts it *"I cannot work on it (the computer) anymore. That would mean that I would have to learn it all over again"* (P2). In other cases, participants primarily stopped using a technology because their needs (or priorities) had changed. For example, a participant who previously had used a home alarm system for security reasons *"Now it is not necessary anymore, I am always at home. When I bought it, I used to still go on vacation regularly"* (P14). Going back to

Sheila's case: although she hardly ever used her iron, she still kept it in her home. In general, we found that participants had a tendency to hold on to devices that they seldom used or had stopped using completely: *"I was born in 1937, I am not used to throwing things away"* (P15). When a device did leave the home, this was usually because it had broken down and was replaced, or because a family member expressed interest in using it.

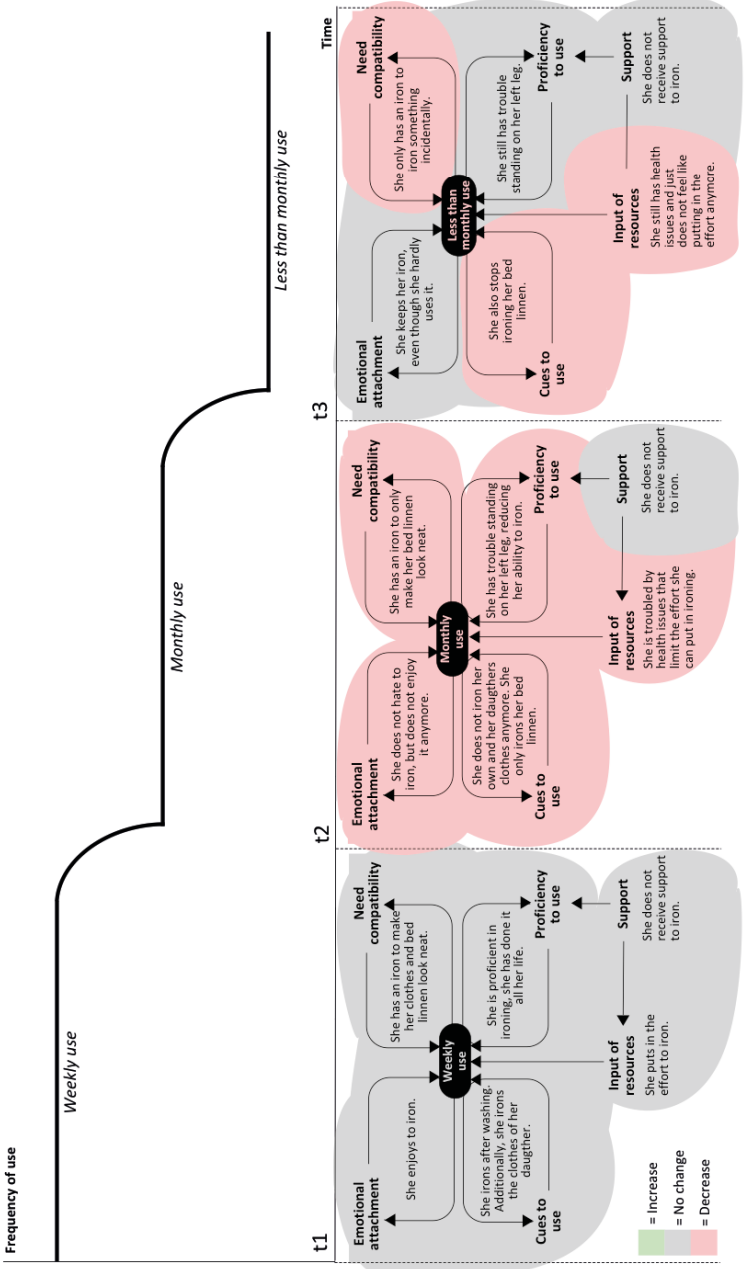

Figure 5. Sheila's use of her iron at time points at t_1, t_2 and t_3

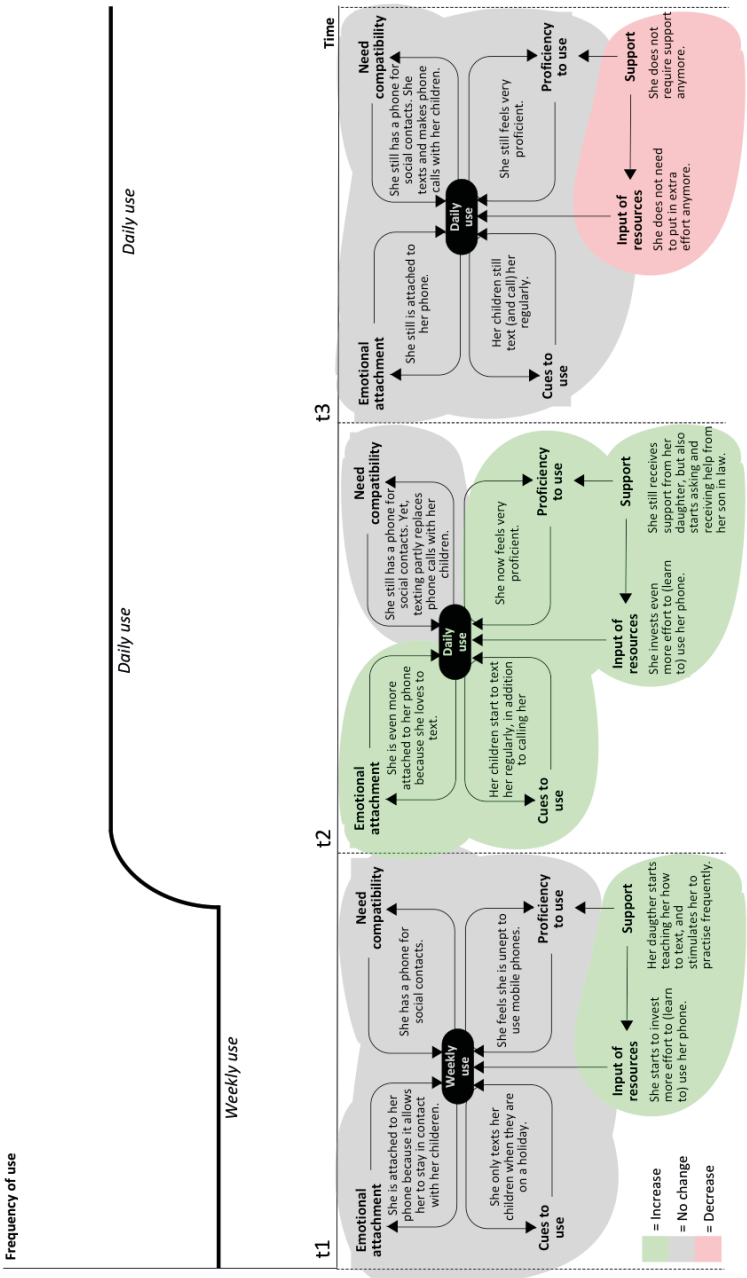

Figure 6. Elly's use of her mobile phone at time points at t_1, t_2 and t_3

In contrast to the abovementioned, an example of increased use is displayed in Figure 6. When we first visited Elly, she used her mobile phone on a weekly basis. She only used it to make telephone calls and did not feel proficient to do anything else with it. However, her daughter had started to teach her how to send text messages, and she encouraged Elly to practice regularly, which she did. The support that Elly received from her children did not come out of the blue. Just prior to participating in the study, she had lost her husband which meant that she was *"on her own",* and this had motivated her children to help her more. At t_2 , Elly's use of her mobile phone had gone from weekly to daily. By that time, Elly felt very proficient in using her mobile phone and was proud of it: *"It may sound crazy, but I consider it a victory"*(P30). There were many cues for her to text with her mobile phone: *"The children all do it. I get a message on my phone, I read it, and quickly send a message back. A quick reply, and I receive another one, and I reply again!"* (P30). She was also more emotionally attached to using her phone: *"I feel I do not want to miss these messages"* (P30). The aforementioned chain of events occurred often in cases in which the use of a multifunctional device (mostly ICT) increased. In these cases, increased use was induced and/or supported by the social network. When we visited Elly at t_3, she still used her mobile phone daily. By that time, she was so familiar with her phone that using it was effortless, and she did not need support anymore. However, Elly had gotten a tablet computer from her children just before t_3. In fact, she started to prefer the tablet over her mobile phone when it came to sending text messages: *"I still use my phone and using it is easy. But I feel that typing on my tablet is more convenient"* (P30), and: *"The tablet is new, but it is actually starting to replace my phone"* (P30). According to Elly, she felt confident that she could use the tablet because of her positive experiences in learning to use her mobile phone. While Elly's case is an example of positive developments leading to an increased use state, there could also be negative or less favorable developments that increased use. One example is decreased health leading to the increased use of assistive technologies. Another example is the disappearance of alternatives to a technology. There was a participant (a widower) who had the habit of eating dinner at his son's house, who was unemployed. The participant described himself as *"not the cooking type"* (P25). This situation changed when his son and his son's wife both got a job. He was now forced to cook considerably more, and did this by making much more use of his microwave oven (for preparing microwave meals). His microwave oven became essential to him: *"I can't do without it. How else am I supposed to prepare meals?"* (P25).

Discussion

The current study sought to explain changes and stability in the use of technologies by independent-living seniors over time. Results showed that a Dynamical Systems Theory (DST) approach was effective in explaining cases of technology use among participants over a period of one and three quarter years. Our findings are summarized in a new dynamical framework that is presented in Figure 7: Dynamics In Technology Use by Seniors (DITUS).

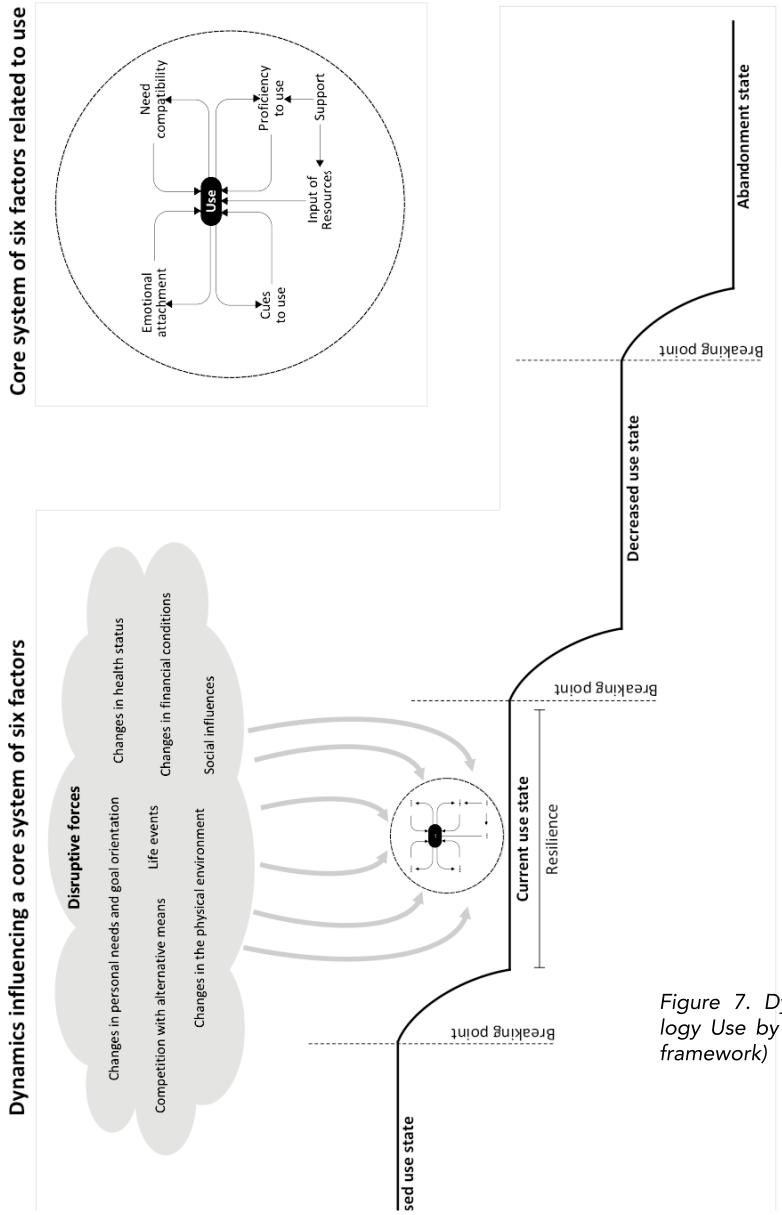

Figure 7. Dynamics In Technology Use by Seniors (the DITUS framework)

We found that there was a core of six interrelated factors that were closely linked to the level of technology use: emotional attachment, need compatibility, cues to use, proficiency to use, input of resources, and support. Additionally, there were disruptive forces that could induce changes to other levels of use by affecting these six factors. Disruptive forces included: social influences, competition with alternative means, changes of personal needs and goal orientation, changes in health status, changes in the physical environment, and changes of financial conditions. Whether or not disruptive forces induced change was dependent on how strong they were, on how long they acted, and on the level of resilience to change. The latter mainly depended on the state of the core of six factors in the first place, and on how quickly and effectively participants and external sources of support responded to disruption. Our results also showed there was overlap between the use of technologies; multiple technologies could address the same needs, proficiency to use could affect multiple technologies, and multiple technologies could tap into the same pool of internal resources and external support. Additionally, the use of multiple technologies could be interrelated because cues to use (specific situations, routines and places inducing use) were linked.

In the literature, there is a lack of longitudinal research on consumers' use of technologies that have been accepted into the home (i.e., post-implementation acceptance) [304,305]. This research gap is also reflected in slow theoretical development. Looking at established theories of individual adoption and acceptance of technology, only the Information Systems continuance model [306] specifically considers the post-implementation stage [307]. The model focuses on confirmation and disconfirmation of beliefs with regards to a technology's usefulness, in order to predict whether an individual is willing to continue use. As such, the model is in line with our concept of need compatibility. However, the model was not developed with older adults in mind, which might explain why it does not address the other factors and dynamics that are described in this study. Our findings are more comparable with a five-week ethnographic study of experiences of young adults who purchased and used an Apple iPhone for the first time [305]. The authors of this study found that functional dependency, emotional attachment and familiarity where most important in participants' experiences with the technology. They also found that ease of use became less of a concernto participants over time [305]. This however differs from the current study, in which we found that - for older adults- the proficiency to use a technology remains crucial, and that external support can play an important role in this respect. The latter is in line

with a recent longitudinal study on older adults' use of mobile ICT devices [308]. The authors of the iPhone study also found that negative experiences with the technology seemed to become less relevant to users' satisfaction as time progressed. We observed a similar pattern, in the sense that negative experiences were sometimes reported by participants, but did not seem to be influential in explaining use.

Seeing that most older adults will go through cognitive, physical and social changes as they age, one could argue that there is a great need for more longitudinal post-implementation research among this target group. In this paper, we have presented a framework for studying technology use dynamics that can be helpful in this pursuit. The strength of the current framework is that it is dynamical minimalist, meaning it is parsimonious without losing depth of understanding [309]. By forming a dynamical model, we believe we were able to identify the simplest mechanisms and fewest variables capable of producing the complex phenomenon in question (i.e., technology use over time by independent-living seniors). Another strength of the framework is that it can be linked to other theories or phenomena. For example, research on how technology use is influenced by the onset and progression of dementia. In terms of our framework, dementia is considered a disruptive force that is expected to influence several of the core of six factors in the framework. It would be interesting to understand which of these factors are affected to which extent (and for how long), which of these factors could possibly compensate for decline in other factors. and how different levels and types of resilience may buffer the effects of dementia on technology use. This could complement previous work on peoples' everyday use of technology while experiencing dementia [310,311]. Additionally, it could be worthwhile to explore links between the DITUS framework and theories of successful aging, such as the Selective Optimization with Compensation model (SOC-model) [26,270]. According to the SOC-model, successful aging is an ongoing and dynamic process in which three processes play an important role: people's Selection of life domains that are important to them, Optimization of means and resources that facilitate success in these domains, and Compensation for losses in these domains [270]. We have observed in our data that the process of selection (i.e., changes in personal needs and goal orientation) can disrupt the current state of use of a technology. With regards to the compensation process: our findings indicate that there can be competition between means that could compensate for losses in domains. Lastly, our findings show that the capacity to optimize of the use of technological means is depended on actions and coping style of

both participants and external sources of support (i.e., resilience).

Several study limitations need to be noted. First, while our framework allowed us to explain and describe the phenomena in our data, this does not mean that our findings are exhaustive. Older adults may experience other (combinations of) disruptive forces than our participants, and these may affect the core six variables in ways we have not encountered. Additionally, studies in other populations are necessary to determine if our results and framework can be transferred to other contexts. Our findings are affected and possibly biased by our beliefs, values, and assumptions. We addressed this 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. Additionally, findings could be susceptible to recall bias, since the interviews were in part retrospective. Other limitations are related to the application of DST. For example, from DST we know that some variables in a dynamical system may fluctuate more quickly than others [302]. Additionally, change is not always proportional to input, meaning small changes can have a dramatic effect on outcomes, or large changes can have a modest effect [299]. Furthermore, feedback loops may not only influence the outcome directly, but may also influence each other [302]. These issues can be addressed better by quantitative empirical testing of the proposed framework.

Recently, it has been argued to define people's health as *"the ability to adapt and self-manage in the face of social, physical and emotional challenges"* [203]. This implicates that technological solutions that aim to support aging in place should (a) be able to adapt to changes that people go through, or (b) be robust in the sense that they can still be used effectively while facing changes, and (c) be capable of mitigating unfavorable changes. To improve sustainability, technological solutions and services can promote three interrelated levels: motivations for use (emotional attachment and need compatibility), opportunities to use (cues to use and proficiency to use), and resources to use (input of resources and support). Additionally, technological solutions, and the people who design and implement them, need to gain understanding on how favorable and unfavorable disruptions influence the aforementioned levels. Aging is complex, dynamic and personal, and this is also reflected in the use of technologies by older people. Periods of stability and periods of change both occur naturally. The DITUS framework can be used as a starting point for understanding stability as well as instability in technology use.

9

General discussion

This thesis aims to advance the understanding of technology acceptance by older adults who are aging in place. In this pursuit, the chapters in this thesis examined (I) differences and similarities between older adults and other stakeholders, when it comes to using technology to support and maintain independence, (II) factors which influence ownership and use of technology by independent-living older adults, and (III) how changes and developments in the lives of older adults influence their acquirement and use of technologies. In the first part of this final chapter, main findings with regards to these research areas are summarized, and compared with the literature. After that, methodological strengths and limitations are discussed. Then, implications and recommendations for research and practice are postulated. Lastly, final conclusions are presented.

Main findings

Part I - Stakeholders' perspectives on using technology to support aging in place

Research in part I of this thesis highlights the growing interest in empowering older adults to age in place by deploying various types of technology. Based on focus group discussions, chapter 2 showed that this interest is shared among technology designers and suppliers, policy makers, and home care and social work professionals. Additionally, there was a shared sense among these stakeholders that older adults' needs and wishes are to be given priority during development and deployment of technologies. This is in line with literature suggesting the importance of user-centeredness [312–314]. Furthermore, the stakeholders felt it is important that technologies provide benefits to older adults, and that older adults are willing and able to use technologies that can help them to age in place. Not unsurprisingly, older adults felt the same way about the importance of the aforementioned issues. At the same time, findings in chapter 2 showed that stakeholders can have different perspectives with regards to the technologies that can be employed, and the work that is needed to implement them. For example, care professionals mentioned considerably fewer types of technology than other stakeholders, and only part of the stakeholders felt the need to collaborate with others outside of their own organization. Literature suggests that these types of differences between stakeholders can seriously handicap or impede the success of technological innovations [75,93]. Furthermore,

The perspectives of older adults are considered important by all stakeholders.

findings in chapter 2 indicated that stakeholders can differ with regards to the interpretation of key issues, such as benefits and affordability. For example, older adults were the only stakeholder that stressed that technology should not provide too many benefits, since this could make people dependent on technology. This difference between stakeholders is illustrated in more depth in chapter 3, which reviewed and discussed literature on older adults' perspectives on independence, and their views on technology for aging in place. In literature and practice, enabling independence is commonly mentioned as a key goal of technology for independent-living older adults [25,28,29,72,315]. However, there is little literature on how older adults' concept of independence relates to technologies that claim to promote independent living. Chapter 3 explains, as was previously reported by Sixsmith [133], that the concept of independence in the eyes of independent-living older adults entails three specific modes or types: (1) being able to look after oneself, not being dependent on others, (2) self-direction; the freedom to do what you want to do, and (3) not feeling obligated to someone. As demonstrated in chapter 3, technology for aging in place can affect these three modes of independence, often simultaneously. While empowering older adults to be able to look after themselves is an important goal of technology, it is also important to realize that technology can, unfavorably, influence older adults' perceived personal freedom and feelings of obligation towards others. For example, using monitoring technology can lead to concerns of being controlled and burdening others (who will have to respond to alarms provided by the system) [38,136,137]. The systematic literature review in Chapter 4 (Part II) confirms this duality in older adults' perspectives on technology for aging in place. Few (implementations of) technologies for aging in place seem to properly address this duality. Therefore, it is expected that broadening the understanding of older adults concept of independence among key stakeholders may result in technological solutions that are more acceptable in the eyes of older adults. Other findings in chapter 4 are explained below.

Stakeholders can interpret key issues differently.

Older adults' concept of independence is not fully understood and addressed.

Part II - Factors influencing technology use by older adults who are aging in place

Part II of this thesis explored factors that influence technology use by older adults who are aging in place. Reasons for older adults' (non)use of technology

designed to support aging in place are under-researched, showed the systematic literature review in chapter 4. More recent systematic reviews confirm this finding [25,36]. As a consequence, it may be difficult to get an accurate picture of older people's responses to the increasing number of technologies that are on the market. As described in chapter 4, existing research on acceptance by older adults is predominantly conducted in the pre-implementation stage (i.e., when a technology has not been used yet in real-life by participants). Pre-implementation studies typically use presentations or scenarios to explain one or more types of technology for aging in place to participants. Sometimes participants are allowed to interact with prototypes of technologies. Chapter 4 criticized this type of research, because it is hard for participants to foresee the future meaning of technologies in their daily lives. Simply put, many older adults do not want to think about a time when they might be needing (technological) support [174,175]. Additionally, older people's needs can change, as well as their (daily) routines. Pre-implementation studies merely indicate participants' initial impressions of technologies they have not experienced personally. If participants in pre-implementation studies state that they would (not) be willing to use technology for aging in place in the future, then this should be interpreted with caution. Furthermore, the majority of studies conducted on older adults' acceptance of technologies use convenience sampling, which may lead to the inclusion of participants who acknowledge their (health related) needs and/or have affinity with the research topic (technological solutions to age in place).

Most research is conducted in the pre-implementation stage.

Pre-implementation research is unapt to capture the role of technology in older adult's daily lives.

As can be seen in Figure 1, acceptance in the pre-implementation stage was influenced by 27 factors, divided into six themes: **concerns** regarding technology (e.g., high cost, privacy implications and usability factors); **expected benefits** of technology (e.g., increased safety and perceived usefulness); **need** for technology (e.g., perceived need and subjective health status); **alternatives** to technology (e.g., help by family or spouse), **social influence** (e.g., influence of family, friends and professional caregivers); and **characteristics of older adults** (e.g., desire to age in place). Chapter 4 also revealed that existing technology acceptances models (i.e., TAM, UTAUT [47,48]) are lacking many of the aforementioned factors. Several other research gaps were also identified: post-implementation research (i.e., when users have used and experienced technology) was scarce, and longitudinal studies could not be found. It was also concluded that it could

Post-implementation research is scarce, and longitudinal research even more so.

be beneficial to research multiple types of technologies at once, since older adults stated they took alternatives into account when deciding to use a certain technology. Whenever participants had alternatives, they perceived less need to start using new technology.

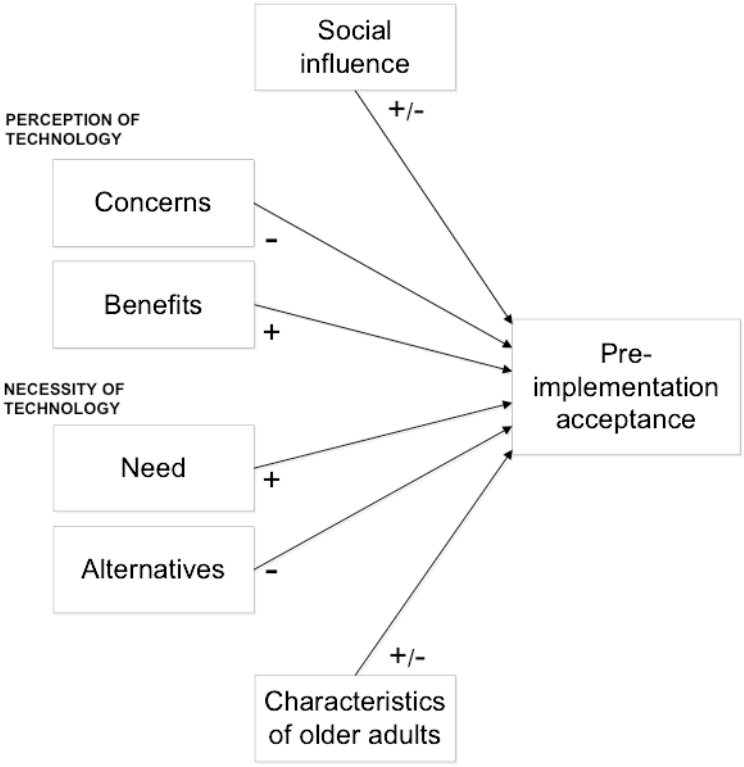

Figure 1. Model of pre-implementation acceptance (chapter 4)

Chapter 5 addressed some of the aforementioned research gaps by conducting a cross-sectional qualitative field study. Participants were interviewed on both pre-implementation (e.g., 'Why are you contemplating on buying this technology?') and post-implementation (e.g., 'Why are you using this technology on a daily basis?') acceptance. This also meant that participants were interviewed on technologies they had in their home and/or naturally came in contact with. In contrast to most studies in the literature review (chapter 4), participants were interviewed on various types of (commonly available) technologies. Results showed that technology use in the context of aging in place was influenced by six major themes: **challenges in the domain of independent living** (e.g., meeting needs, health decline); **behavioral options** (e.g., making use of technology, making use of human assistance); **personal thoughts on**

technology use (e.g., need, interest, consequences); **influence of the social network** (e.g., advice, support); **influence of organizations** (e.g., technology suppliers and home care providers), and **the role of the physical environment** (e.g., fit with home interior) (see Figure 2). The field study added to the findings of the review in chapter 4, by providing more detail on technology-related beliefs and attitudes, by discerning multiple types of social influence, and by adding the role of organizations, the physical environment and challenges in the domain of independent-living. While comparable technology-related beliefs and attitudes were also found in other studies [11,111,186,194,195], chapter 5 in particular showed that older adults' perceptions and use of technology were embedded in their personal, social and physical context. A contextual understanding is required to better capture reasons for use and non-use.

Older adults' perceptions and use of technology are embedded in their personal, social, and physical context.

Looking specifically at the social context, chapters 5 and 6 showed that spouses and family members played an important role in both the acquirement of technologies (i.e., pre-implementation acceptance) as well as in using the technologies once they were in the home (i.e., post-implementation acceptance). These members of the social network impacted technology use by offering advice, by providing support, and by acting as a co-user. Additionally, members of the social network brought older adults in contact with technologies that were new or unfamiliar to them. The influence of the social network was very prevalent: all participants who were in contact with family members and/or had a spouse were influenced by them when it came to using technology. This also meant that participants who did not have a (strong) social network were very much disadvantaged when it came to acquiring and using technology. Additionally, chapter 5 showed that independent-living older adults not only take personal consequences into account when making decisions on acquiring and using technology, they also consider consequences for the social network.

The social network is key in acquiring and using technology.

These findings are congruent with Roger's seminal work on diffusion of innovations that emphasizes that technology adoption is a social process in which communication plays an important role [129]. Classical models of (older adults') technology acceptance largely overlook the multi-faceted influence of the social network [46,47,56,173,174]. Furthermore, chapters 5 and 6 showed that members of the social network may have various reasons for exerting influence, and that these reasons may not be in line with older adults' needs

and wants. For example, participants were given mobile phones by their children for reasons of safety, also when participants themselves did not feel unsafe.

Grandchildren can play a positive role in promoting technology acceptance.

In general older adults do not want to burden their children with technology related questions (see chapter 4). However, chapter 6 showed that participants were much less reluctant in asking their grandchildren for help. Furthermore, participants easily adopted their grandchildren's enthusiasm for technology; indeed, they were more willing to accept technology that their grandchildren liked. The role of grandchildren in older adults' technology acceptance is very much under-researched in current literature.

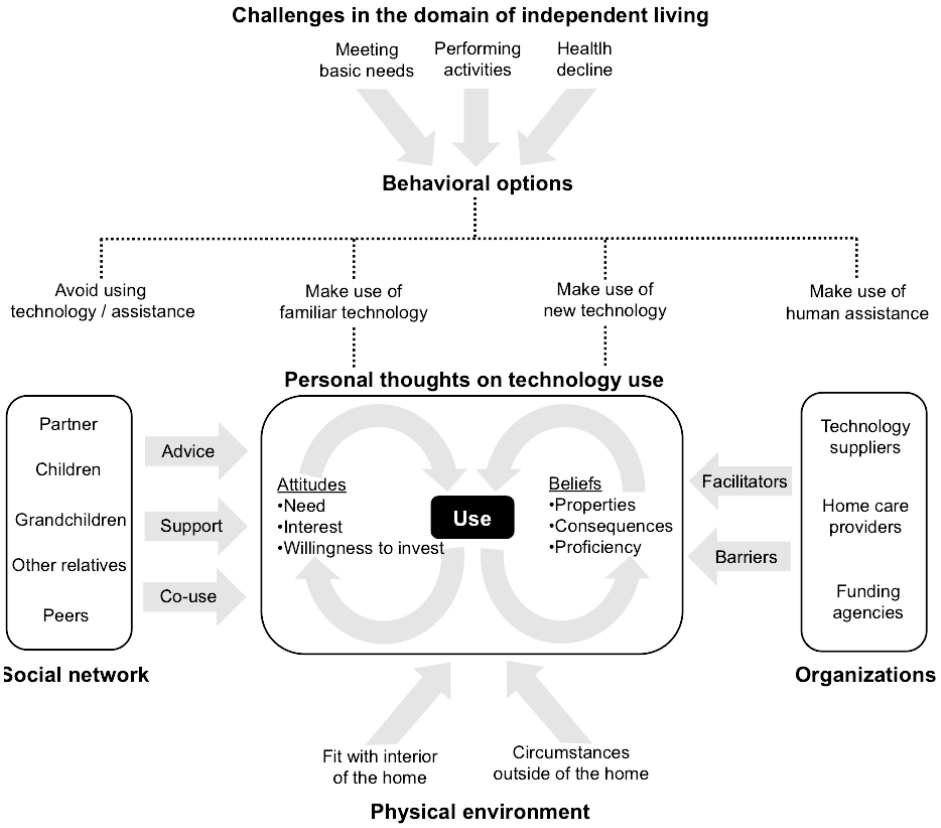

Figure 2. Conceptual model of (pre-and post-implementation) factors influencing the level of technology use by older adults who are aging in place (chapter 5)

Part III - Dynamics in technology use by older adults who are aging in place

Older adults' adoption of technology has been described as a *"complex issue that is affected by multiple factors"* [63]. To more fully understand technology acceptance by independent-living older adults, insight in the interplay and dynamics between these factors is needed. It seems particularly important to understand which core factors directly influence acquirement and use, and how contextual factors (such as those described in part II) influence these core factors over time. The longitudinal qualitative field research in this thesis provided a unique opportunity to explore and capture these dynamics. While others have stated the need for this type of research [40–43], we are not aware of longitudinal studies that are similar to those that are presented in this part of the thesis.

Acquirement of technologies

In chapter 7, it was investigated how and why technologies are acquired by independent-living older adults; and how these acquired technologies subsequently affected their lives. A realist approach [260,261] was used to better understand the contexts, mechanisms and outcomes of technology acquirements. Findings were accumulated in a new conceptual model: The Cycle of Technology Acquirement by Independent-Living Seniors (C-TAILS). The model (see figure 3) depicts how various types of technology acquirement originate from an independent-living senior's specific **status quo**, and various possible **decisive developments** within that status quo. Subsequently, the model shows how these decisive developments can trigger a number of **acquirement enabling mechanisms**, and how acquirement can be influenced by personal and situational **moderating factors**. Lastly, the model depicts the consequences (or **implications**) of technology acquirement, which are mediated by the seniors' experiences with the newly acquired technology. As such, the C-TAILS model provides an integrative perspective on why and how technologies are acquired, and why these may or may not prove to be appropriate and effective, considering an independent-living senior's needs and circumstances at a given

The C-TAILS model depicts and integrates both the origins and consequences of technology acquirements by independent-living older adults.

Technologies that are acquired in ways that are not congruent with older adults' personal needs and circumstances run a higher risk of proving to be ineffective or inappropriate.

point in time. Using the model, scenarios of technology acquirements can be captured and understood. Chapter 7 described scenarios with both origins and consequences of technology acquirements. As such, it was demonstrated that externally driven and purely desire-driven acquirements led to a higher risk of suboptimal use and low levels of need satisfaction. Our findings also highlighted that older adults' needs and circumstances are subject to change. The C-TAILS model can be used to study the optimal timing of technology acquirements.

Many participants were not actively seeking to use new technology to age in place.

In line with other research [3–5], most participants in the longitudinal field study wanted to keep living independently. However, for most participants, the interviews were the first time they thoroughly reflected upon their reasons for using technology. The thought of using technology with the specific goal of enabling or maintaining independent living rarely entered participants' minds. Additionally, chapter 7 showed that in some situations older adults act as consumers who make their own choices, while in other situations they are in a more passive role and are provided with technologies by their environment, and in yet other situations they work together with their environment to acquire technologies. Most of the technology acquirements by participants themselves were aimed at preserving the status quo, rather than seeking new ways to improve current or future independent living.

Post-implementation acceptance

As previously mentioned, longitudinal studies on the use of technologies that have been accepted into the home (i.e., post implementation acceptance) are very scarce. In fact, chapter 4 and other studies indicate [25,304,305] that this is possibly the biggest research gap in the literature on technology acceptance by independent-living senior. Chapter 8 addressed this gap by reporting findings of a longitudinal qualitative field study. To better understand changes and stability in the use of technologies by independent-living seniors, interviews were held on reasons for stable, increased, declined and stopped use of technologies. In aiming to understand changes and stability in frequency of use of technologies over time, a dynamical systems theory approach was used during analysis [298]. In dynamical systems, variables can serve as both dependent and independent variables at the same time, in contrast to linear (non-dynamical) models. Feedback loops play an important role [300]. Together, one or more feedback loops of variables form a 'system' of

interacting components. The state of a system can be challenged by external disturbances. In chapter 8, longitudinal case descriptions were used to explain shifts to other frequencies of use.

Findings in chapter 8 accumulated to a new framework of Dynamics In Technology Use by Seniors (DITUS). As can be seen in Figure 4, this framework entails:

The DITUS framework aids in understanding both stability as well as instability in technology use.

(a) **a system of six interrelated factors** that were closely linked to the frequency of use of a technology:emotional attachment, need compatibility, cues to use, proficiency to use, input of resources (i.e., effort and money, and support);

(b) **overlap** between technologies; multiple techno-logies could address the same needs, proficiency to use could affect multiple technologies, and multiple technologies could tap into the same pool of internal resources and external support. Additionally, the use of technologies could be interrelated because cues to use (specific situations, routines and places inducing use) were linked;

Disruptive forces can alter the frequency of use of one or more technologies, by affecting a core of 6 interrelated factors.

(c) **disruptive forces** that could influence the six interrelated factors. Disruptive forces included social influences, changes in health status, changes of personal needs and goal orientation, competition with alternative means, changes in the physical environment, and changes of financial conditions;

(d) varying (individual) levels of **resilience** to disruption. Personal characteristics played a role here (i.e., active vs. passive coping style, willingness to ask for support). Additionally, resilience was dependent on how quickly and effectively external sources of support responded to disruption.

In some cases, use is more resilient to change than in other cases.

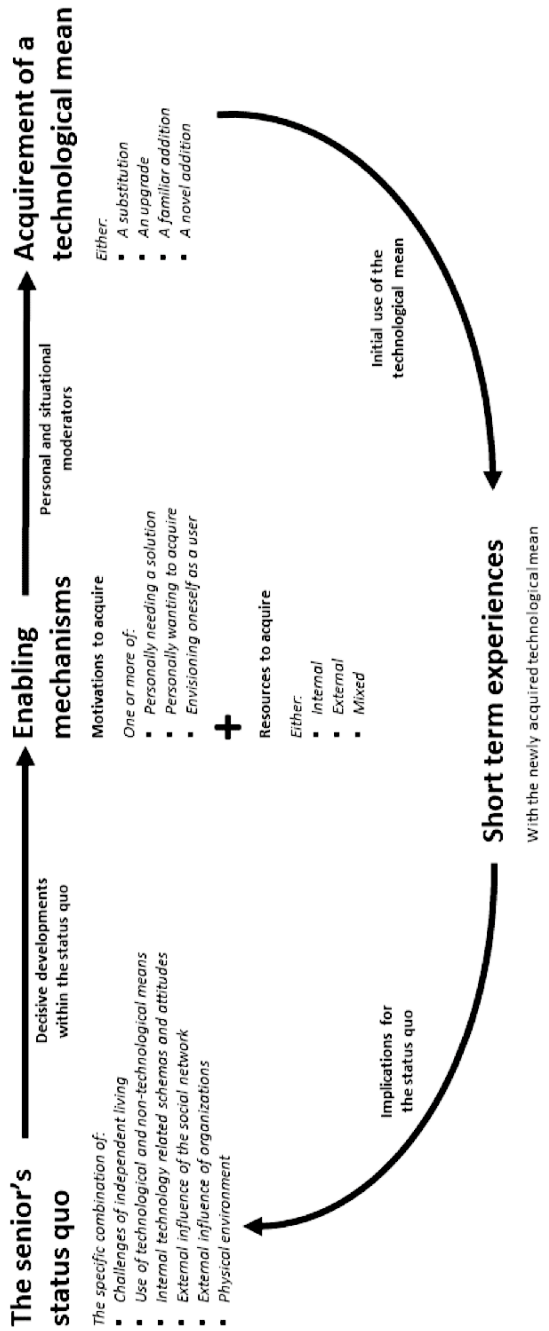

Figure 3. Cycle of Technology Acquirement by Independent-Living Seniors (the C-TAILS model) (chapter 7)

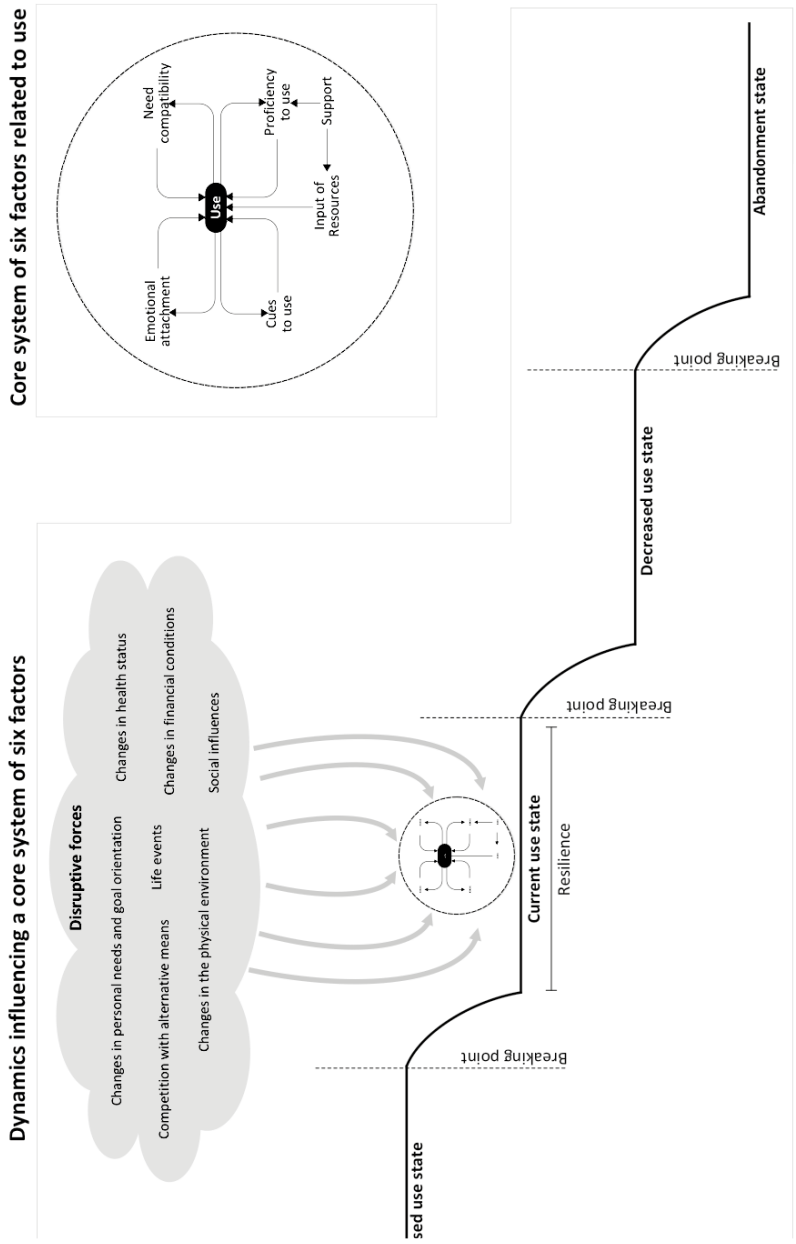

Figure 4. Dynamics In Technology Use by Seniors (the DITUS framework) (chapter 8)

Findings in Part II and III of this thesis indicate that the value of a technology product (in the eyes of older adults) is relative, and can fluctuate due to changing needs, changing product-related skills, and competing technological and non-technological alternatives to the product. This notion has important implications. Looking at existing technology acceptance literature, it has been argued that early research was primarily focused on barriers to technology use and negative aspects of technology in the eyes of older adults [316,317]. Since then, researchers have broadened their scope, and started to also focus on facilitators of technology use by older adults. Perceived benefits and positive aspects of technology use were given more attention. In the literature, perceived usefulness and perceived need became frequently researched variables (see chapter 4, and [62,63]). However, frequently reported low technology adoption rates in literature and practice indicate that the understanding of technology acceptance by independent-living older adults is still not comprehensive. The research in this thesis provides a new perspective: both negative and positive aspects of technology are dependent on the older adults' personal, social and technological context, and this context is subject to change. In other words, to fully understand independent-living older adults' technology acceptance, it is necessary to be sensitive to issues of context and timing.

The value of technology is relative, and subject to change.

Methodological strengths and limitations

The main strength of this thesis lies in its application of qualitative longitudinal research. Cross-sectional qualitative studies are limited to what could be described as *"contextualized snapshots of processes and peoples"* [318]. Longitudinal Qualitative Research (QLR) adds depth, by allowing the understanding of how and why participants' feelings and thoughts about an issue change over time. Furthermore, QLR enhances the understanding of multiple causal factors in complex systems [256,318,319]. Moreover, the use of QLR allows for the challenging and exposing of the static character of existing theoretical frameworks, in the case of this thesis: classical models of technology acceptance. In this way, this thesis hopefully can give rise to new theoretical development [318]. Lastly, QLR methods were applied rigorously. To elicit better data, follow-up interviews were partly tailor-made for each participant as they were asked specific questions based on their previous answers and experiences. Furthermore, member checking procedures were extensive, and two-thirds of the transcripts were peer-coded.

However, qualitative research is also incredibly labor intensive [256,318,319]. In particular, a longitudinal data set effectively triples the analytic burden by demanding cross sectional analysis of each wave, longitudinal analysis across waves, and an articulation of the two [256]. The author can fully attest to this: cross-sectional analysis was finished in the spring of 2015, but further analysis required considerable efforts over the course of 2 more years. To quote Holland, Thomson and Henderson: *"The greatest danger of a major qualitative longitudinal study is that it becomes an 'albatross', constrained by the weight of its research design and a burden on those responsible for keeping it moving"* [256].

Another strength is the focus on post-implementation research, which is scarce [11]. This type of research is particularly important in light of the new definition of health that is proposed by Huber et al.: *"the ability to adapt and self-manage in the face of social, physical and emotional challenges"* [203]. This definition implicates that technologies that aim to support aging in place should (a) be able to adapt to changes that people go through, or (b) be robust in the sense that can still be used effectively while facing changes, and (c) be capable of mitigating unfavorable changes. In order to achieve these goal, the type of post-implementation research that is reported in this thesis is crucial.

Lastly, the research in this thesis was designed to understand the role of multiple types of technologies simultaneously. In doing so, findings pointed to the important role of competing technological and non-technological alternatives in older people's technology acceptance. Many previous studies and models have missed this important dimension, as they often were only focused on studying one technology, or a small set of technologies.

The research in this thesis may be limited or biased in several ways. First, findings may be affected and possibly biased by the authors' beliefs, values, and assumptions. Considerable efforts were made to mitigate this and promote reflexivity, by working in alternating pairs during data collection and analysis, and by critically evaluating the design and findings in group discussions involving all co-authors.

Second, as this thesis focused on older adults' perspectives, this also implicated that social processes and influences were studied through their eyes only. As such, this thesis does not fully capture the role of technology in couple and family relationships, as well as the social networks' perspective on technology use to age in place. Previous research suggests that family ties can be complex, and that themes such as independence, intimacy, asymmetry and reciprocity play a role [138,320,321].

Third, some of the studies (chapter 5,6 and 7) relied on participants' recollection of events, experiences, and developments. Participants' hindsight may not be completely accurate, with the degree of accuracy varying on the basis of the technology's salience to the individual, the length of time over which recall is requested, and individual differences in variables such as education and memory functioning. As such the field research is susceptible to recall bias [178]. Efforts were made to limit recall bias, by only including participants with normal cognitive functioning, by specifically asking participants for positive and negative experiences, and by discussing information put forward by participants that differed from previous interviews with them. A related limitation is that, in the field studies (chapters 5,6,7 and 8), self-reported technology use was measured. Studies based on self-reported use may show different results with studies employing direct usage measurement (i.e., objective use) [53,237]. This implies that the findings cannot readily be compared with findings from studies that directly measure use.
Fourth, while the work in this thesis emphasized the dynamics in the lives of older adults, technology is for the most part considered static. This is mainly due to the focus on the use of hardware (i.e. various types of devices) instead of software. In reality, particularly ICT-devices can change over time, as software is updated, added or removed. Furthermore, recent Internet panel studies conducted by us showed that older adults also vary considerably with regard to the activities they do on ICT devices [322,323].
Lastly, the empirical studies in this thesis focus on the role of context, and how context can influence use behavior and technology-related beliefs and attitudes. However, certain personality traits may also influence technology acceptance, such as consumer innovativeness [324,325] and the Big Five personality traits (i.e., conscientiousness, extraversion, agreeableness, openness to experience, and neuroticism) [326]. Some personality traits play a role in the C-TAILS an DITUS models, namely impulsiveness, openness to experience, willingness to ask for help, and coping style. However, both models may not fully address the role of personality. Literature suggests that personality traits may directly impact technology use, or indirectly, via technology-related beliefs [326,327].

Implications and recommendations for research and practice

In this paragraph, implications for research and practice will be discussed jointly, since both are expected to influence and benefit each other.

As mentioned previously, the value of a technology (in the eyes of older adults) is relative, and can fluctuate over time, due to mechanisms that are

described in the C-TAILS and DITUS models. Acknowledging the relative value of technology makes apparent that **technology acceptance by older adults can be improved by effective allocation** (i.e., pairing the right technology with the right individual at the right time). While considerable resources are invested in designing and developing technological solutions [315], the research in this thesis indicates it could be worthwhile to also invest in improving allocation. Pairing technologies with individuals (or vice versa) can be challenging [70,101]. On the one hand, there is the aging population, which is highly heterogeneous [249–251]. On the other hand, there is the industry, which is putting an increasing number of technological solutions on the market [28,315]. Effective allocation is likely to require (1) an understanding of each older individual's specific needs and circumstances, (2) an understanding of the technological offerings that are available, and (3) approaches, tools and policies that facilitate the meeting of individuals and technological offerings.

Understanding each older individual's specific needs and circumstances

The C-TAILS and DITUS models can both be used to understand specific needs and circumstances of independent-living older adults. C-TAILS can be used for assessing an older individual's specific status quo, to understand his or her specific needs and circumstances, in order to determine if technologies in line with these needs would be a welcome addition. DITUS can be used for understanding stability as well as instability in the use of technologies by older individuals. Ideally, both models are adapted, refined and extended, by using them in practice and research. For example, using the models in other contexts than in which the research was conducted may reveal additional decisive developments and disruptive forces. Understanding the optimum context and timing for technology use also means acknowledging that technology may not always be the most optimal solution, at a certain point in time. In some cases alternatives to a technology may be available, that are more desirable in the eyes of older adults. Additionally, some technologies may be more affordable than others [328]. Furthermore, there could be a mismatch between technologies that are on the market and the persons' needs and circumstances. Research suggests that a combination of technologies that is tailored to individual preferences is most effective in promoting aging in place [72]. The goal should not be to provide independent-living older adults with as much technology as possible, but rather to provide older adults with solutions that are personally relevant to them.

Understanding technological offerings that are available

Pairing older adults with technologies requires not only an understanding of older adults needs and circumstances, but also of technological offerings that are available. In practice, it is often challenging for individuals and organizations to get an overview of technologies that are on the market. This is chiefly due to the fact that the market of technologies for independent-living older adults is dynamic: new technologies are entering the market frequently, and at the same time, technologies are also disappearing from the market [315]. Additionally, the quality, safety and costs of technologies may not always be transparent [329–331]. Getting an accurate overview and understanding of available technologies requires considerable and continuous scoping and evaluation efforts. Practice and (applied) researchers need to work together in this respect, so that allocation, acceptance, and ultimately outcomes of technologies can be optimized.

It is important to note that the (cost-)effectiveness of technologies may differ, depending on the context in which they are used and the person that is using them. For example, some technologies may require more or different skills than other technologies. Or, the advantages (and disadvantages) of technologies may depend on contingencies such as the physical and technological infrastructure. If technologies are to be matched with older adults in the population, then it is important to understand what is effective for whom, in what circumstances, and why. In this pursuit realist evaluation can be a useful approach [260,261]. Realist evaluation is designed to improve understanding of how and why interventions work or do not work in particular contexts [263]. Although not the focus of this thesis, it is clear that only evaluating the (cost-) effectiveness of technologies in clinical trials with limited external validity is insufficient to determine what technologies are beneficial to what members of the aging population.

Approaches, tools and policies that facilitate the meeting of individuals and technological offerings

Findings in this thesis with regards to the important role of the social network make clear that **technology acceptance by older adults benefits from mediation**. As long as there is technological development, there will likely exist a gap between those that grew up with certain technologies, and those that did not [146–148]. As a consequence, older adults can benefit from people around them who can help them come in contact with technologies, and who can also help them use technologies. These people do not have to be members of the

social network, they can also be professionals or volunteers who are trained in understanding both older adults and technologies. In the future, mediation could possibly be provided by a *"technology recommendation service"*, meaning a technology (i.e., an app, a website) that can provide personalized advice to older adults with regards to using technologies to support their needs.

In the process of mediation it is important to acknowledge that older adults in some cases will actively seek (technological) solutions and/or support in using technologies, while in other cases they take on a more passive or reluctant role. Ideally, mediation is flexible enough to accommodate for both types of cases. This also implicates that mediation needs to be sensitive to issues of context and timing. Results in this thesis indicate that when it comes to technology acceptance, it may be more effective to wait for 'windows of opportunity' (i.e., moments when older adults are more willing and able to use technology), than to offer older adults technologies that they see no need for. Ideally, mediators (i.e., people and services that have an understanding of both older adults and technological offerings) would monitor and learn over time what decisive developments and personal motivations influence independent-livings older adults' technology readiness, and organize the allocation of technological solutions accordingly. Lastly, mediation should not stop after technologies are acquired by older adults. As demonstrated in this thesis, favorable and unfavorable disruptions influence the level of use of technologies, and external support is an important factor in maintaining use.

Improving the design and implementation of technologies for aging in place

It is important to note that, apart from improving allocation of existing technologies, findings in this thesis can also benefit the design of new technologies for aging in place. Others have pinpointed that many designers typically have little understanding of the unique needs of older adults [28,46,139]. This may be because technology designers are usually considerably younger than older adults, which means they may be too unfamiliar with (psychological) aspects of aging, and grew up using other types of technology in comparison to older adults. Furthermore, for technology designers it can be challenging to take into account the changing circumstances and characteristics of users in product, system and service design. In particular, the findings in this thesis highlight the importance of understanding how a technology product 'sits' in older adults lives. The C-TAILS and DITUS models in this thesis can be of benefit, as they provide guidance with regards to (contextual) factors and dynamics that are important in designing technologies for independent-

living older adults. Furthermore, the C-TAILS and DITUS models can also be of help in evaluating and examining how designs are used in real-life contexts. In a similar manner, the research and models in this thesis can be used to improve the way technologies are implemented (i.e. installed and configured) in the homes of independent-living older adults. Recent studies suggest that there is much that can be improved in this respect, and that understanding post-implementation use is key to improving installation and configuration procedures and processes [46,222].

All in all, the above-mentioned implications and recommendations highlight that acceptance research can benefit and inform research on the design, allocation, mediation and implementation of technologies. Conversely, findings in design, allocation, mediation and implementation research can also inform and benefit acceptance research (Figure 5). In the figure, the work in this thesis is displayed in the center (#1). Additionally, the author has acquired funding for a project at the intersection of allocation and acceptance research (#2). This involves a PhD project to investigate how big data can be employed to optimize the personalized allocation of eHealth interventions to individuals, thereby increasing the chances of successful acceptance and thus health benefits. Furthermore, funding was acquired for a project that employs the C-TAILS model to improve both allocation as well as mediation of technologies for independent-living (#2 and #3). Lastly, grant applications are pending for research that combines design and acceptance research using the DITUS model (#4), and research on how older adults can help each other in using technology (#3). Combining technology acceptance research with adjacent applied research areas is expected to contribute to bridging the gap between the heterogeneous and evolving population of older adults and the growing number of technological offerings that aim to support aging in place.

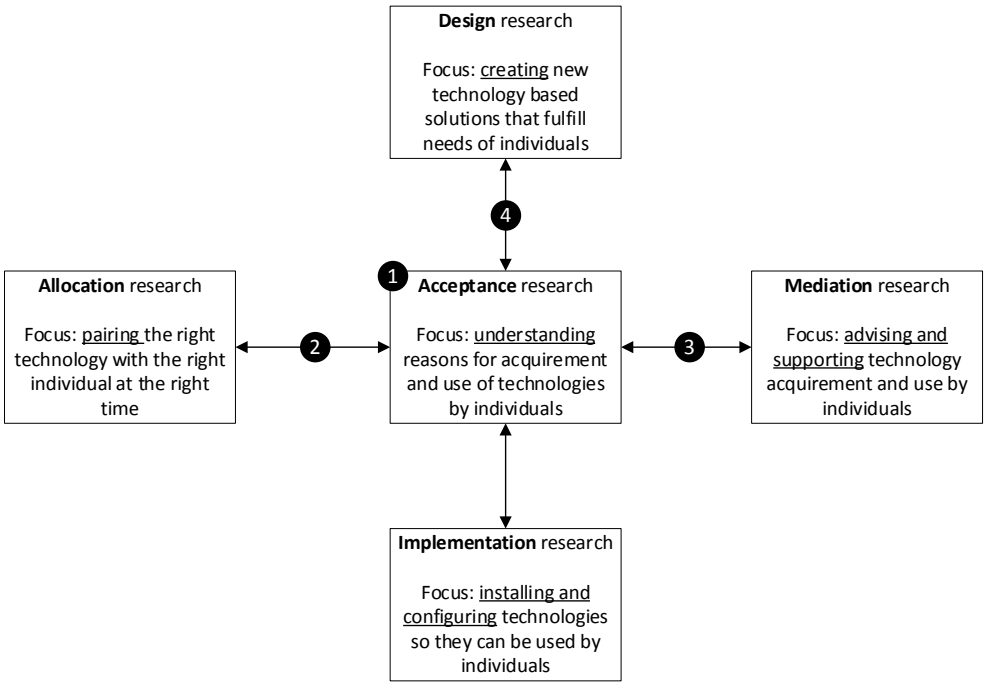

Figure 5. Mapping of the author's work in technology acceptance and adjacent applied research areas

General conclusion

Aging is complex, dynamic and personal. Findings show that this is also reflected in the various ways in which independent-living older adults acquire and use technologies. To improve (the understanding of) technology acceptance by older adults who are aging in place, approaches need to harness complexity, be sensitive to developments over time, and embrace individuality. In this pursuit the C-TAILS and DITUS models that are presented in this thesis offer a new and promising perspective to researchers and practice.

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Samenvatting

Wereldwijd vergrijst de bevolking in een rap tempo. Wanneer we naar Nederland kijken, dan is de prognose dat binnen 25 jaar een kwart van de bevolking zal bestaan uit 65-plussers. Nieuwe technologie kan het leven van deze ouderen een stuk aangenamer maken, maar technologie kan ook ingewikkeld zijn, en zorgen voor ongemak. Tegenwoordig wordt er veel verwacht van technologie als hulpmiddel om ouderen te helpen bij het zelfstandig wonen. Maar wat zorgt er nu voor dat een ouder iemand technologie in huis neemt of krijgt? En wat zorgt ervoor dat hij of zij technologie blijft gebruiken? Dit proefschrift hanteert een brede definitie van technologie ter bevordering van zelfstandig wonen, van een magnetron om zelf maaltijden te bereiden tot sensoren die alarm kunnen slaan wanneer iemand valt in zijn of haar eigen huis. Uit eerder onderzoek blijkt dat wetenschappers geen compleet beeld hebben van factoren die bij technologie acceptatie door ouderen een rol spelen. Bovendien is er nauwelijks tot geen inzicht in hoe veranderingen in de levens van ouderen doorwerken in hun technologiegebruik. Ook blijkt uit eerder onderzoek dat ouderen mogelijk anders over technologie denken dan andere belanghebbenden zoals zorgprofessionals, technologie-aanbieders, en beleidsmakers vermoeden. Dit proefschrift heeft daarom als doel om op diverse manieren meer inzicht te bieden in technologieacceptatie door zelfstandig wonende ouderen.

Het proefschrift bestaat uit drie delen die hieronder kort worden samengevat. Het eerste deel richt zich op verschillen en overeenkomsten tussen ouderen en andere belanghebbenden waar het gaat om het inzetten van technologie ter bevordering van zelfstandig wonen bij ouderen. Het tweede deel behandelt factoren die van invloed zijn op bezit en gebruik van technologie door zelfstandig wonende ouderen. Het derde en laatste deel beschrijft de diverse manieren waarop veranderingen en ontwikkelingen in de loop van de tijd het verkrijgen en het gebruiken van technologie door ouderen beïnvloeden. Vervolgens wordt beknopt weergegeven wat sterkten en zwakten van het proefschrift zijn, en welke aanbevelingen geformuleerd zijn voor wetenschap en praktijk. De samenvatting sluit af met een algemene conclusie.

Deel I - Perspectieven van belanghebbenden op het inzetten van technologie ter bevordering van zelfstandig wonen door ouderen

Onderzoek in deel I van dit proefschrift laat zien dat er een groeiende interesse is om ouderen door middel van technologie te helpen bij het zelfstandig wonen. Uit de focusgroep studie in hoofdstuk 2 blijkt dat deze interesse gedeeld wordt door technologie ontwerpers en leveranciers, beleidsmakers, en zorg- en welzijn professionals. Onder deze belanghebbenden heerst bovendien het gevoel dat de behoeften en wensen van ouderen voorop moeten staan wanneer het gaat om het ontwikkelen en implementeren van technologieën. De belanghebbenden vinden het ook belangrijk dat technologie voordelen biedt voor ouderen, en dat ouderen technologie willen en kunnen gebruiken. Niet geheel verrassend word deze mening gedeeld door ouderen zelf. Tegelijkertijd kunnen belanghebbenden verschillende visies hebben met betrekking tot technologieën die ingezet kunnen worden. Zo denken zorgprofessionals aan aanzienlijk minder soorten technologieën dan andere belanghebbenden. Qua het werk dat nodig is om technologieën te implementeren verschilt men ook van mening. Zo vindt slechts een deel van de belanghebbenden het belangrijk om samen te werken met partijen buiten de eigen organisatie. Uit eerder onderzoek weten we dat dit soort verschillen belangrijke gevolgen kunnen hebben voor het succes van de inzet van technologische innovaties. Hoofdstuk 2 laat bovendien zien dat belanghebbenden kernzaken als de gewenste voordelen en betaalbaarheid anders kunnen interpreteren. Zo zijn ouderen de enigen die benadrukken dat technologie ook weer niet teveel voordelen moet bieden, om te voorkomen dat mensen er afhankelijk van worden. Dit verschil in denken is verder uitgediept in hoofdstuk 3. In dit hoofdstuk wordt aan de hand van bestaande literatuur besproken hoe ouderen denken over zelfstandigheid, en technologie ter bevordering van zelfstandig wonen. In de dagelijkse praktijk en in de wetenschappelijke literatuur wordt het bevorderen van zelfstandigheid alom genoemd als reden voor het inzetten van technologie. Tegelijkertijd wordt er weinig onderzoek gedaan naar of de manier waarop ouderen zelfstandigheid beleven wel aansluit bij technologische oplossingen die claimen zelfstandig wonen te bevorderen. Hoofdstuk 3 laat zien, zoals Sixsmith al eerder vond, dat het begrip zelfstandigheid voor ouderen drie betekenissen heeft: (1) niet afhankelijk zijn van anderen, (2) de vrijheid hebben om te doen wat je wilt, en (3) je niet schuldig of verplicht voe-

Alle belanghebbenden vinden de mening van ouderen belangrijk.

Belanghebbenden kunnen kernzaken rondom technologie verschillend interpreteren.

Er wordt niet goed genoeg aangesloten bij wat zelfstandigheid inhoudt voor ouderen.

len richting anderen. Technologie ter bevordering van zelfstandig wonen kan alle drie deze betekenissen van zelfstandigheid beïnvloeden, vaak gelijktijdig en soms zelfs tegenstrijdig. Dus, het bevorderen dat ouderen minder afhankelijk zijn van anderen is een belangrijk doel, maar het is goed om te beseffen dat technologie een negatieve invloed kan hebben op persoonlijke vrijheid en gevoelens van verplichting richting anderen. Zo kan sensor monitoring technologie bijvoorbeeld leiden tot het gevoel gecontroleerd te worden en het gevoel anderen (diegenen die zullen moeten reageren bij een gesignaleerde calamiteit) teveel te belasten. De systematische literatuurstudie in deel II van dit proefschrift bevestigt deze dualiteit in de relatie tussen technologie en zelfstandigheid. Slechts weinig (implementaties van) technologie besteden hier voldoende aandacht aan. Het is daarom aan te raden dat belanghebbenden een breder begrip krijgen van wat zelfstandigheid voor ouderen inhoudt. Op deze manier kunnen technologische oplossingen meer acceptabel worden voor ouderen.

Deel II – Factoren die van invloed zijn op technologiegebruik door zelfstandig wonende ouderen

In deel II van dit proefschrift is onderzocht welke factoren van invloed zijn op het gebruik van technologie door zelfstandig wonende ouderen. De systematische literatuurstudie in hoofdstuk 4 laat zien dat de redenen van ouderen om technologie (niet) te gebruiken nog niet volledig zijn onderzocht. Gevolg hiervan is dat het moeilijk is om een accuraat beeld te krijgen van hoe ouderen reageren op het toenemende aantal technologieën dat op de markt komt. Hoofdstuk 4 toont aan dat het meeste onderzoek naar technologie acceptatie door zelfstandig wonende ouderen zogenaamd pre-implementatie onderzoek is. Dit houdt in dat ouderen wordt gevraagd wat ze van technologie vinden, terwijl ze deze technologie niet in het dagelijks leven hebben gebruikt. In dit type onderzoek wordt vaak door middel van een korte presentatie uitleg gegeven over één of enkele technologieën. Soms mogen deelnemers prototypen van technologieën in een lab gebruiken. Maar, het is voor deelnemers moeilijk om te voorzien wat het gebruiken van technologie voor hun dagelijks leven zal betekenen. Bovendien willen veel ouderen liever niet nadenken over het feit dat

Het meeste onderzoek is pre-implementatie

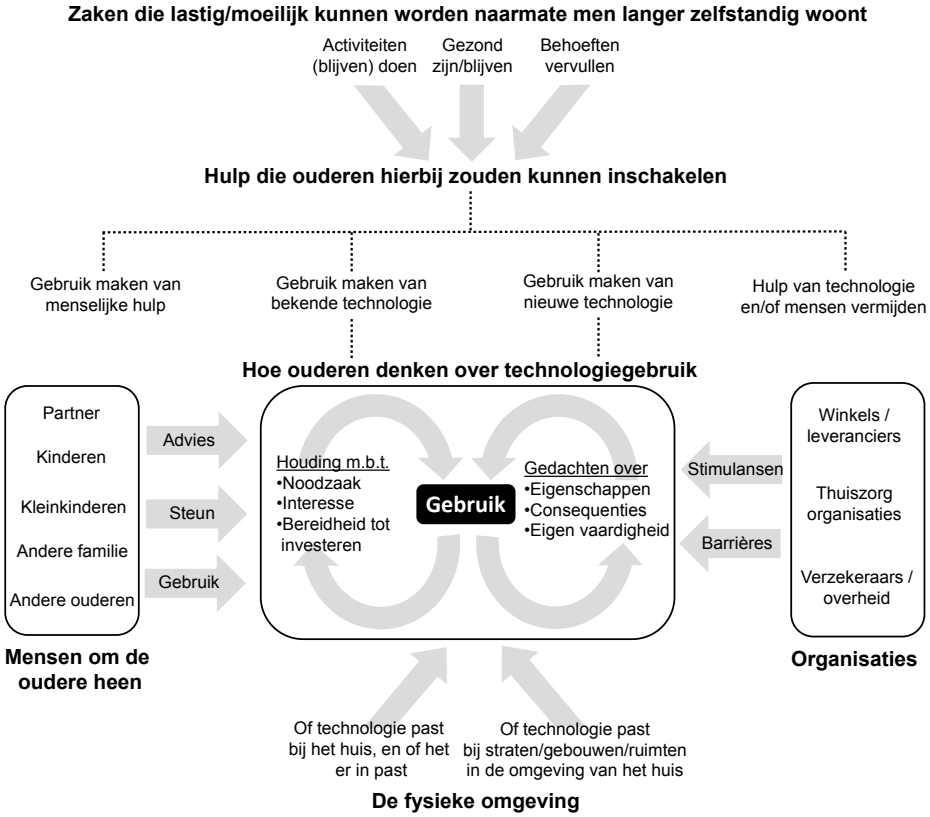
Pre-implementatie studies zijn ongeschikt om te begrijpen wat de rol van technologie is het dagelijks leven van

er ooit een tijd kan komen waarin ze (technologische) hulp hard nodig kunnen hebben. Daarbij staan de levens van ouderen niet stil, behoeften kunnen veranderen evenals (dagelijkse) routines. Pre-implementatie studies geven enkel een beeld van de eerste indruk van ouderen over technologieën die ze niet zelf hebben gebruikt. Wanneer ouderen in dit soort studies aangeven dat ze (niet) van plan zijn om een technologie te gebruiken, dan moet opgepast worden om hier zware conclusies aan te verbinden. Uit de systematische literatuurstudie in hoofdstuk 4 blijkt verder dat in pre-implementatie studies de mening van ouderen over technologie wordt beïnvloedt door 27 verschillende factoren, verdeeld over zes thema's: **zorgen over technologie** (bijv. kosten, privacy en gebruiksvriendelijkheid), **verwachte voordelen van technologie** (bijv. veiligheid en minder druk op mantelzorgers), **behoefte aan technologie** (bijv. subjectieve noodzaak en subjectieve gezondheid), alternatieven voor technologie (bijv. hulp door een familielid of partner), **sociale invloeden** (bijv. door bekenden en familie), en **eigenschappen van ouderen** (bijv. de wil om zelfstandig te blijven wonen). In al bestaande technologie acceptatie modellen (bijv. TAM en UTAUT) missen veel van de voorgenoemde factoren. Ook is gebleken dat post-implementatie onderzoek (waarbij deelnemers technologie daadwerkelijk in gebruik hebben genomen) schaars is. Longitudinaal onderzoek (d.w.z. onderzoek waarbij deelnemers meerdere malen worden onderzocht) werd helemaal niet gevonden. Verder werd er in hoofdstuk 4 geconcludeerd dat het nuttig zou zijn om meerdere technologieën tegelijk te onderzoeken, omdat ouderen ook naar alternatieven kijken wanneer ze nadenken over het gebruiken van een technologie. Wanneer er alternatieven voorhanden zijn dan voelen ouderen minder noodzaak om een nieuwe technologie te gaan gebruiken.

Post-implementatie onderzoek is schaars en longitudinaal onderzoek al helemaal.

In hoofdstuk 5, en in de hoofdstukken in deel III, wordt onderzoek gerapporteerd dat zich richt op de hiervoor genoemde tekortkomingen in de huidige literatuur. Hoofdstuk 5 beschrijft een kwalitatief veldonderzoek waarbij ouderen eenmalig in de eigen woning werden geïnterviewd over hun pre-implementatie acceptatie (bv. 'Waarom denkt u na over het gaan gebruiken van deze technologie?') en hun post-implementatie acceptatie (bv 'Waarom gebruikt u deze technologie dagelijks?'). In het onderzoek zijn ouderen bevraagd over technologieën die ze in huis hadden en/of over technologieën waarmee ze in hun leven in contact kwamen. Met deelnemers is gesproken over meerdere technologieën. Uit de resultaten bleek dat technologiegebruik wordt beïnvloedt door zes hoofdthema's (zie Figuur 1). Ten eerste zijn er diverse **zaken die**

lastig/moeilijk kunnen worden naarmate men langer zelfstandig woont (bijv. behoeften vervullen, gezond blijven). Om met de verschillende uitdagingen op het gebied van het zelfstandig wonen om te kunnen gaan zijn er verschillende vormen van **hulp die ouderen zouden kunnen inschakelen** (bijv. gebruikmaken van technologie, gebruikmaken van menselijke hulp). Wanneer technologie een optie is dan wordt het belangrijk om te begrijpen **hoe ouderen denken over technologiegebruik** (bijv. hoe noodzakelijk vindt men technologie, heeft men interesse in technologie, welke consequenties ervaart/verwacht men). Hoe ouderen denken over technologiegebruik wordt weer beïnvloedt door **mensen om de ouderen heen** (bijv. advies en steun door kinderen), **organisaties** (bv. winkels/leveranciers en thuiszorgorganisaties), en **de fysieke omgeving** (bijv. of technologie past bij het huis).



Figuur 1. Conceptueel model van (pre- en post-implementatie) factoren die het gebruik van technologie door zelfstandig wonende ouderen beïnvloeden (hoofdstuk 5)

Het bovenstaande model laat vooral zien dat wat ouderen denken en voelen bij technologiegebruik is ingebed in een persoonlijke, sociale en fysieke context. Een goed begrip van de gehele context is nodig om technologiegebruik door ouderen te kunnen snappen.

Hoe ouderen denken over technologiegebruik is afhankelijk van hun persoonlijke, sociale en fysieke context.

Wanneer we specifiek kijken naar de sociale context, dan laten de hoofdstukken 5 en 6 zien dat partners en familieleden (met name kinderen en kleinkinderen) een belangrijke rol spelen bij zowel het in huis krijgen als het gebruiken van technologie door ouderen. Leden van het sociale netwerk geven advies, boden ondersteuning, maar ze kunnen zelf ook een gebruiker zijn. Bovendien brengen zij ouderen in contact met technologieën die nieuw voor hen zijn. Alle ouderen in het onderzoek met een sociaal netwerk werden door hen beïnvloedt in hun technologiegebruik. Voor ouderen zonder een (sterk) sociaal netwerk was het dan ook moeilijker om technologie te verkrijgen en te gebruiken. Verder blijkt dat ouderen, als ze nadenken over technologie, niet alleen persoonlijke consequenties van het gebruik van technologie in ogenschouw nemen; ze denken ook na over de consequenties voor hun sociaal netwerk.

De rol van sociale netwerk is cruciaal, waar het gaat om het verkrijgen en gebruiken van technologie.

De voorgaande bevindingen zijn in overeenstemming met Rogers' bekende boek over verspreiding van innovaties, waarin hij benadrukt dat technologie adoptie/acceptatie vooral een sociaal proces is. Bestaande technologie acceptatie modellen besteden echter beperkt aandacht aan sociale invloeden. De resultaten uit de hoofdstukken 5 en 6 laten ook zien dat het sociale netwerk verschillende redenen kan hebben om invloed uit te oefenen. Als deze redenen niet aansluiten bij de behoeften en wensen van ouderen zelf, is de kans groot dat de technologie niet gebruikt wordt. Met het oog op veiligheid gaven kinderen bijvoorbeeld een mobiele telefoon aan hun ouders. Ouderen die zichzelf niet onveilig voelden gebruikten deze mobiele telefoon nauwelijks of niet. Over het algemeen willen ouderen hun kinderen niet belasten, ook niet met vragen over technologie. Maar, hoofdstuk 6 laat zien dat ouderen dit gevoel veel minder hebben bij hun kleinkinderen. Bovendien is voor ouderen het enthousiasme van hun kleinkinderen voor technologie aanstekelijk: ze waren meer bereid om technologie te accepteren waar hun kleinkinderen positief over zijn. De rol van kleinkinderen bij technologiegebruik door ouderen is nog nauwelijks aan bod gekomen in wetenschappelijke literatuur.

Kleinkinderen kunnen een positieve rol spelen bij het bevorderen van technologie acceptatie.

Deel III – Dynamiek in technologiegebruik door zelfstandig wonende ouderen

Eerder is door anderen al benadrukt dat acceptatie van technologie door ouderen een complexe kwestie is waarbij veel verschillende factoren een rol spelen. Om technologie acceptatie beter te kunnen begrijpen is inzicht in het samenspel en de dynamiek tussen deze factoren noodzakelijk. Het longitudinale kwalitatieve veldonderzoek dat is beschreven in deel III van dit proefschrift bood een unieke mogelijkheid om dit te bestuderen. Andere onderzoekers hebben benadrukt dat dit type onderzoek noodzakelijk is, maar voor zover de promovendus weet bestaat er geen onderzoek dat vergelijkbaar is met dit deel van het proefschrift.

In hoofdstuk 7 is onderzocht hoe en waarom zelfstandig wonende ouderen in het bezit komen van technologieën. Realistische evaluatie (Pawson & Tilley) is gebruikt om contexten, mechanismen en uitkomsten van technologieverkrijging te begrijpen. Ouderen werden meerdere malen geïnterviewd over technologieën die zij in hun bezit kregen. Bevindingen zijn samengevat in een nieuw conceptueel model: the Cycle of Technology Acquirement by Independent-Living Seniors (C-TAILS). Dit model (zie Figuur 2) geeft de verschillende manier waarop ouderen technologie verkrijgen weer.

Het C-TAILS model geeft inzicht in oorsprong en gevolgen van het verkrijgen van technologie door ouderen.

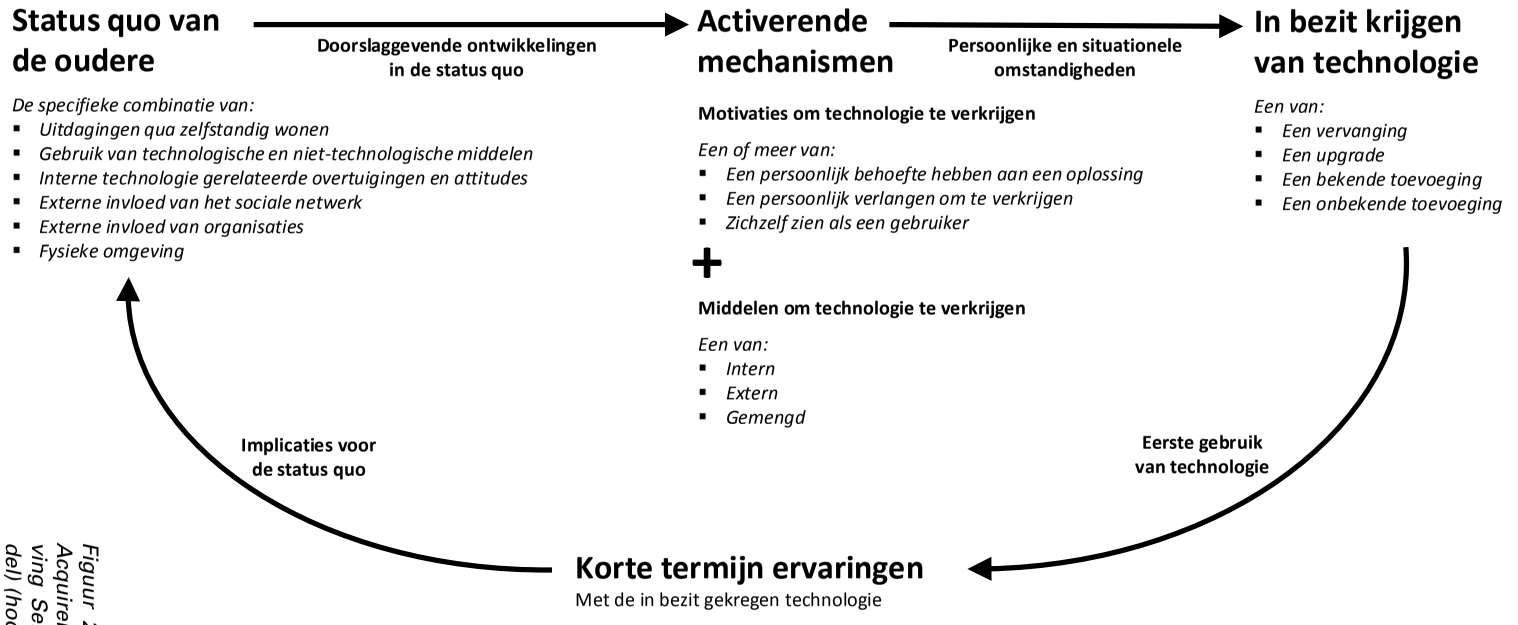
Het verkrijgen (het in het bezit krijgen van technologie) begint bij een specifieke **status quo van de oudere** waarin **doorslaggevende ontwikkelingen** plaatsvinden. Vervolgens laat het model zien hoe deze doorslaggevende ontwikkelingen **activerende mechanismen** in gang zetten, en hoe in bezit krijgen van technologie beïnvloedt wordt door **persoonlijke en situationele omstandigheden**. Tot slot besteedt het model aandacht aan de implicaties van het in bezit krijgen van technologie. Deze implicaties worden beïnvloedt door **korte termijn ervaringen met de in bezit gekregen technologie**. Het C-TAILS model biedt een integraal perspectief op waarom en hoe technologieën zijn verkregen, en waarom deze al dan niet tijdig, passend en effectief zijn, uitgaande van de specifieke behoeften en omstandigheden van een oudere. Met behulp van het model kunnen scenario's van het in bezit krijgen van technologie geanalyseerd en beschreven worden. In hoofdstuk 7 zijn voorbeelden van dit soort scenario's beschreven. Uit een analyse van deze scenario's bleek dat extern gedreven en puur door verlangen verkregen technologie een groter risico loopt om suboptimaal te worden gebruikt. Ook worden de behoeften van ouderen in die

Technologie die is verkregen op een manier die niet aansluit bij individuele behoeften en omstandigheden is vaker niet passend en ineffectief.

gevallen niet goed bevredigd. Hoofdstuk 7 liet vooral zien dat behoeften en omstandigheden van ouderen aan verandering onderhevig zijn. Het C-TAILS model kan gebruikt worden om er achter te komen wat de optimale timing is voor het verkrijgen van technologie.

De meeste ouderen die deelnamen aan het onderzoek wilden zo lang mogelijk zelfstandig blijven wonen. Als gevolg van hun deelname aan het onderzoek reflecteerden de meeste ouderen voor het eerst op hun eigen technologiegebruik. De gedachte dat technologie gebruikt zou kunnen worden om zelfstandig wonen te bevorderen kwam niet of nauwelijks bij deelnemende ouderen op. Daarnaast bleek in hoofdstuk 7 dat ouderen in sommige situaties vooral zelf besluiten of ze technologie in huis nemen, terwijl zij zich in andere situaties vrijwel helemaal laten leiden door hun omgeving. Ook bestaat er een mengvorm, waarbij ouderen samen met hun omgeving bepalen of en hoe ze technologie in huis nemen. In gevallen waarin ouderen zelf de beslisser zijn valt op dat de aanschaf vooral bedoeld is om de huidige situatie te verbeteren, en niet om zelfstandig wonen in de toekomst beter mogelijk te maken.

De meeste ouderen waren niet actief op zoek naar technologie die zou kunnen helpen bij het zelfstandig wonen.



Figuur 2. Cycle of Technology Acquirement by Independent-Living Seniors (het C-TAILS model) (hoofdstuk 7)

Hoofstuk 8 gaat over duurzaam gebruik van technologie. Er is onderzocht waarom technologiegebruik door ouderen stabiel blijft of juist verandert in de loop van de tijd. In post-implementatie onderzoek zijn ouderen meerdere malen geïnterviewd over redenen voor stabiel, gestegen, gedaald en gestopt gebruik van technologie. Bij het analyseren van de interviews is gebruik gemaakt van dynamische systeem theorie. De bevindingen zijn samengevat in een nieuw raamwerk: Dynamics In Technology Use by Seniors (DITUS). Zoals te zien is in Figuur 3 bevat het raamwerk een aantal onderdelen:

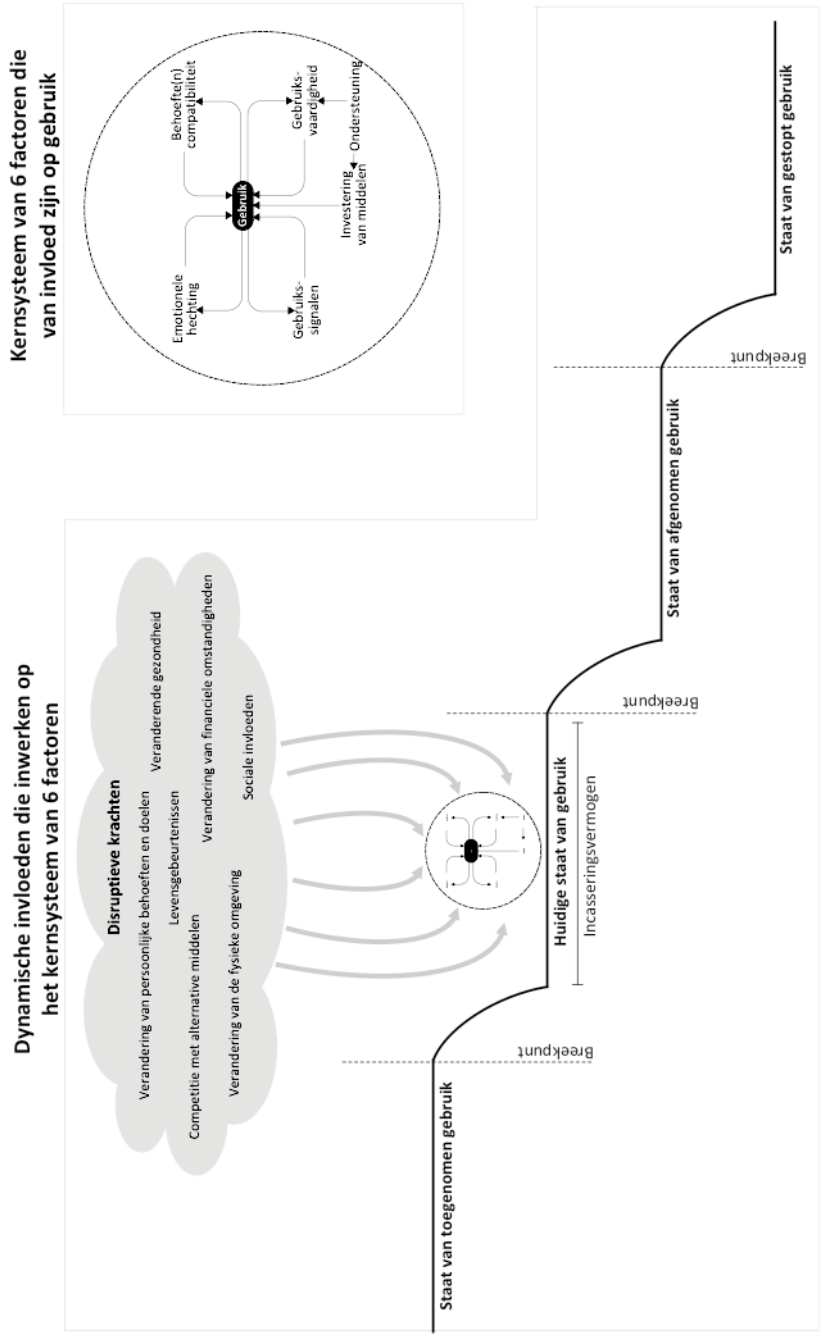
(a) **een kernsysteem van 6 aan elkaar gerelateerde factoren** die samen van invloed zijn op de frequentie van het gebruik: (1) emotionele hechting, (2) behoefte(n) compatibiliteit, (3) gebruikssignalen, (4) gebruiksvaardigheid, (5) investering van middelen en (6) ondersteuning;

(b) er bestaat **overlap** tussen technologieën: meerdere technologieën kunnen dezelfde behoefte bevredigen, gebruiksvaardigheid kan invloed hebben op meerdere technologieën en meerdere technologieën kunnen aanspraak doen op dezelfde (beperkte) middelen en ondersteuning. Daarnaast kunnen verschillende technologieën gelinkt zijn aan dezelfde gebruikssignalen (d.w.z. specifieke situaties, routines en plekken die gebruik opwekken);

(c) er zijn diverse **disruptieve krachten** die inwerken op het kernsysteem van de 6 factoren: verandering van persoonlijke behoeften en doelen, veranderende gezondheid, levensgebeurtenissen, competitie met alternatieve middelen, verandering van financiële omstandigheden, verandering van de fysieke omgeving en sociale invloeden;

(d) individuele verschillen qua **incasseringsvermogen**. Dit heef onder andere te maken met hoe snel externe bronnen van ondersteuning reageren op disruptie en met karaktereigenschappen van ouderen (o.a. een actieve of passieve coping stijl en de bereidheid om hulp te vragen).

De mate waarin technologiegebruik bestand is tegen disruptieve krachten verschilt



Figuur 3. Dynamics In Technology Use by Seniors (het DITUS raamwerk) (hoofdstuk 8)

Bevindingen in deel II en III van dit proefschrift wijzen erop dat de waarde van technologie in de ogen van ouderen relatief is, en bovendien kan fluctueren onder invloed van o.a. veranderende behoeften, veranderingen qua gebruiksvaardigheid en veranderingen in de beschikbaarheid van technologische en niet- technologische alternatieven. Deze notie verschilt van eerdere literatuur over technologie acceptatie door ouderen. De eerste technologie acceptatie onderzoeken richtten zich voornamelijk op barrières voor technologiegebruik en negatieve aspecten van technologie in de ogen van ouderen. Later zijn wetenschappers zich ook gaan richten op zaken die technologiegebruik door ouderen faciliteren. Positieve aspecten c.q. voordelen van technologiegebruik kregen meer aandacht. In de literatuur werden gepercipieerd nut en subjectieve noodzaak veelgenoemde variabelen. Maar, de vaak gerapporteerde beperkte acceptatie van technologie door ouderen wijst erop dat ons begrip van technologie acceptatie nog niet diepgaand en/of uitgebreid genoeg is. Het onderzoek in dit proefschrift biedt een nieuw perspectief: zowel negatieve als positieve aspecten van technologie zijn afhankelijk van de persoonlijke, sociale en technologische context waarin ouderen verkeren. En deze context is bovendien aan verandering onderhevig. Om technologie acceptatie door ouderen beter te kunnen begrijpen is het dus nodig om sensitief te zijn voor wat betreft context en timing.

De waarde van technologie is relatief en vatbaar voor verandering

Sterkten en zwakten van het proefschrift

De kracht van het proefschrift zit hem vooral in de gebruikte methode: longitudinaal kwalitatief veldonderzoek. Hierdoor werd meer inzicht in dynamiek mogelijk, wanneer het gaat om technologiegebruik door ouderen. Hiermee sluit het proefschrift ook goed aan bij de nieuwe definitie van gezondheid zoals deze is geformuleerd door Huber en collega's: *"het vermogen om zich aan te passen en een eigen regie te voeren, in het licht van de fysieke, emotionele en sociale uitdagingen in het leven."* Deze definitie impliceert dat technologieën ter bevordering van zelfstandig wonen (a) zich moeten kunnen aanpassen aan veranderingen die ouderen ondergaan, of (b) robuust moeten zijn in de zin dat ze nog steeds gebruikt kunnen worden ook al zijn er veranderingen, en (c) de effecten van negatieve veranderingen in de levens van ouderen moeten kunnen beperken. De inzichten in dit proefschrift kunnen hier een belangrijke bijdrage aan leveren.

Beperkingen van het proefschrift zijn vooral gerelateerd aan de methode die werd gebruikt. Het onderzoek was kwalitatief, wat kan betekenen dat het is

gekleurd door de overtuigingen, waarden en aannames van de promovendus. Door veel in groepsverband te werken met Fontys collega's en begeleiders is geprobeerd om dit risico te beperken. Het onderzoek deed ook een beroep op het geheugen van de deelnemers. Er is geprobeerd om geheugenfouten te beperken door ouderen die cognitieve problemen hadden uit te sluiten van het onderzoek, door zowel naar positieve als naar negatieve ervaringen te vragen, en door antwoorden te vergelijken met eerdere interviews met dezelfde deelnemer. Tot slot moet opgemerkt worden dat het onderzoek verkennend van aard was. Het doel was om verschillende patronen van technologiegebruik te vinden, door een groep van ouderen intensief te volgen. Uit vervolgonderzoek moet blijken of de resultaten van dit proefschrift te generaliseren zijn naar de gehele populatie van ouderen.

Aanbevelingen voor wetenschap en praktijk

Uit dit proefschrift blijkt dat de waarde van technologie in de ogen van ouderen relatief is en aan verandering onderhevig. Dit houdt in dat **technologie acceptatie door ouderen verbeterd kan worden door effectieve allocatie** (d.w.z. de juiste technologie aan de juiste persoon aanbieden op het juiste tijdstip). Momenteel wordt er veel geld en energie gestopt in het ontwikkelen van nieuwe technologische oplossingen terwijl resultaten in dit proefschrift suggereren dat er nog veel winst te behalen door de allocatie van al bestaande technologie te verbeteren. Dit vereist (1) begrip van de individuele behoeften en omstandigheden van ouderen, (2) begrip van de beschikbare technologische oplossingen, en (3) tools, methoden en beleid om oudere individuen te koppelen aan passende technologische oplossingen.

Begrip van de individuele behoeften en omstandigheden van ouderen

De C-TAILS en DITUS modellen kunnen gebruikt worden om specifieke behoeften en omstandigheden van ouderen te bestuderen en te begrijpen. Met C-TAILS kan de zogenaamde status quo van de oudere in kaart gebracht worden, om vervolgens te bepalen of technologische oplossingen een welkome aanvulling zijn. Met behulp van DITUS kan zowel stabiliteit als instabiliteit in het gebruik van technologie door ouderen beter begrepen worden. Idealiter worden beide modellen aangepast, verfijnd en verbeterd door ze in de praktijk en in onderzoek te gebruiken. Op deze manier kunnen bijvoorbeeld nieuwe doorslaggevende ontwikkelingen en disruptieve krachten aan het licht komen. Meer begrip krijgen van de optimale context en timing voor technologie houdt ook in te erkennen dat technologie soms niet de meest optimale oplossing

is. Soms kunnen niet-technologische alternatieven aantrekkelijker zijn, of meer betaalbaar. Het kan ook voorkomen dat er een 'mismatch' is tussen de behoeften en omstandigheden van een oudere en het technologisch aanbod. Het doel zou niet moeten zijn om ouderen van zoveel mogelijk technologie te voorzien, maar om technologie voor ouderen beschikbaar te maken die voor hen persoonlijk relevant is.

Begrip van de beschikbare technologische oplossingen

Weten welke technologische oplossingen er op de markt zijn is essentieel om ouderen te kunnen koppelen aan passende en beschikbare technologie. In de praktijk is het voor consumenten en organisaties vaak moeilijk om een overzicht te hebben van beschikbare technologische oplossingen. Dit komt met name doordat het aanbod dynamisch is: technologische oplossingen komen beschikbaar en verdwijnen weer. Daarnaast zijn kwaliteit, veiligheid en kosten van oplossingen vaak niet transparant. Het voorgaande betekent dat constant gescand moet worden of er nieuw technologische oplossingen zijn, en dat nieuwe oplossingen steeds weer geëvalueerd moeten worden. Het gaat hier om aanzienlijke inspanningen die geleverd moeten worden; onderzoekers en praktijkpartners kunnen elkaar hierin helpen.

Tools, methoden en beleid om ouderen te koppelen aan passende technologische oplossingen

Uit dit proefschrift blijkt dat **ouderen bij technologiegebruik veel baat hebben bij 'bemiddeling'**. Het is aannemelijk dat er altijd een gat zal bestaan tussen diegenen die met een technologie zijn opgegroeid en diegenen die hier niet mee zijn opgegroeid. Dat betekent dat ouderen veel kunnen hebben aan mensen om hen heen die nieuwe technologieën aan hen kunnen introduceren en die ook ondersteuning kunnen bieden bij het gebruik. Dit 'bemiddeling' kan gedaan worden door professionals of vrijwilligers die getraind zijn in het begrijpen van behoeften van ouderen en het technologisch aanbod kennen. Hierbij is het van belang om te beseffen dat ouderen soms actief op zoek zullen gaan naar (technologische) oplossingen terwijl ze zich andere keren passief of terughoudend zullen opstellen. Resultaten in dit proefschrift wijzen erop dat het effectiever kan zijn om te wachten op het juiste moment om technologie aan te bieden, dan om technologie aan te bieden op momenten waarop ouderen hier niet voor open staan. Idealiter wordt er gemonitord en geleerd wat optimale momenten zijn, en wordt de allocatie van technologie hierop afgestemd. Van belang is ook om de bemiddeling niet te stoppen nadat een tech-

nologie in gebruik is genomen. Zoals dit proefschrift laat zien staan de levens van ouderen niet stil en externe ondersteuning is een belangrijke voorwaarde voor duurzaam gebruik.

Het design en de implementatie van technologieën verbeteren

Naast het verbeteren van allocatie kan dit proefschrift ook bijdragen aan het verbeteren van het design van technologie ter bevordering van het zelfstandig wonen door ouderen. Door anderen is reeds benadrukt dat technologie ontwerpers nog weinig begrip hebben van de behoeften en wensen van ouderen. Dit kan komen omdat zij vaak aanzienlijk jonger zijn dan ouderen, wat betekent dat ze minder bekend zijn met (psychologische) aspecten van het ouder worden. Ook zijn beiden groepen niet met dezelfde technologieën opgegroeid. De C-TAILS en DITUS modellen kunnen gebruikt worden om beter te begrijpen en te evalueren of een technologieproduct past bij (de diverse) levens van ouderen. Op een soortgelijke manier kan dit proefschrift ook bijdragen aan het verbeteren van de installatie en configuratie van technologieën in de huizen van ouderen. Recent onderzoek laat zien dat er nog veel te verbeteren valt op dit vlak.

Algemene conclusie

Ouder worden is een dynamisch proces. Het is ook een persoonlijk en complex proces. De bevindingen in dit proefschrift laten zien dat dit ook geldt voor de verschillende manieren waarop zelfstandig wonende ouderen technologie verkrijgen en gebruiken. Om technologie acceptatie door zelfstandig wonende ouderen te verbeteren is het noodzakelijk dat we om kunnen gaan met complexiteit, dat we gevoelig zijn voor ontwikkelingen over de tijd, en dat we aandacht hebben voor het individu. De C-TAILS en DITUS modellen in dit proefschrift geven wetenschap en praktijk de gelegenheid om op een nieuwe en veelbelovende manier te zorgen dat technologie beter past bij de leefwereld van ouderen.

Dankwoord

Terugkijkend op de afgelopen periode zou ik graag een aantal mensen willen bedanken. Ten eerste wil ik mijn oprechte dank uitspreken richting de deelnemers aan het onderzoek, en dan met name de dames en heren die ons jarenlang in hun eigen woning hebben ontvangen. Bedankt voor uw vertrouwen en gezelligheid! Ik vond het heel leerzaam om met u allen te spreken.
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Daarnaast wil ik een aantal Fontys Paramedische Hogeschool collega's bedanken met wie ik jarenlang het veldonderzoek en een belangrijk deel van het analysewerk heb verricht: Maurice, Marianne, Sil en Claire. Zonder jullie had ik dit absoluut niet gekund. Wat hebben we hard en veel gewerkt. En wat een mooi werk hadden we! Door anderen te interviewen leerden we veel over onszelf. En door samen kwalitatief te analyseren leerden we veel over elkaar :P Maurice: heerlijk om urenlang met je te discussiëren over de gevonden codes en over wat deze al dan niet betekenden. Claire: wanneer de anderen me helemaal zat waren dan begreep je mij nog steeds! Jij bent zo goed. Marianne: ik weet nog goed hoe je al direct mails naar jan en alleman aan het typen was, nog terwijl we tijdens overleggen beslissingen namen. Ik ben jaloers op je energie. Sil: naast al je hulp heb je me de beste schrijftip uit mijn carrière gegeven, ik gebruik hem nog bij elk artikel!
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LEV Groep, Seniorenraad Helmond, Domovisie, Gemeente Helmond, Simpact, Vertizon. Summa Zorg, Welzijn en Techniek, ROC Ter AA Zorg en Welzijn, het Opleidings- en ontwikkelingsfonds voor het Technisch Installatiebedrijf (OTIB), Fontys Hogeschool Mens en Gezondheid/Toegepaste Gerontologie, en Fontys Hogeschool Techniek en Logistiek. Vergeef me dat ik niet de ruimte heb om iedereen er persoonlijk uit te lichten. Bedankt voor het meedenken en meewerken aan het onderwijsmateriaal Anne-Mie, Susan, Klaas, Roos, Hans en Ilse. Willem, bedankt voor je kritisch blik gedurende het hele project. Je bewaakte echt de vertaalslag naar de technische installatie praktijk. Stephan jij hebt misschien wel de meest diverse werkzaamheden voor het project verricht, van analysewerk tot dagvoorzitter zijn.. ! Peter, Eveline, Ronnie en Els: hartelijk dank voor het werven van onze deelnemers. Maartje en Annette wat was het leuk en nuttig om jullie in de projectgroep te hebben! Bedankt voor jullie steun.

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Curriculum vitae of the author

Sebastiaan Peek was born in the Netherlands, on the 22th of July 1978. Ever since hitting puberty Sebastiaan has been fascinated by computers. He used to love reading computer manuals form cover to cover. Gradually, he learned more about the computer's inner workings, and got to know the power of computers. They were controlled environments in which he could experiment and play. These experiences led him to study Communication systems (BSc) after finishing high school. He became an ICT specialist and worked in several projects, in various roles, i.e., improving user experience and usability, writing functional specifications, and web and database development. However, he also learned that in practice, ICT was hardly ever deployed in 'controlled environments'. There were a lot of things that could go wrong when designing and implementing ICT, and there was no book that adequately could explain how users 'work'. He decided to study Psychology (BSc, and MSc Work and Organizational Psychology), so he could improve the use of technology in practice.

Since becoming a psychologist, Sebastiaan has been involved in conducting research. First, as a policy researcher at the Institute of Applied Social Sciences (Radboud University), and later as a PhD candidate/lecturer at Fontys University of Applied Sciences (Chair of Health Innovations and Technology) and Tilburg University (Tranzo). During his PhD research, he saw firsthand how independent-living seniors are different from each other, and how they are different from themselves at different times. His PhD work focuses on dynamics of technology use and on how motivations change over time and are dependent on context. Sebastiaan's work has been published in top quartile journals in health care sciences and services, medical informatics and gerontology. He has secured several research grants and won various awards for his research and educational projects. Sebastiaan was a guest researcher at Stanford University, Persuasive Technology Lab, and is involved in the Personal User Experience (PUX) task force of the European Innovation Partnership on Active and Healthy Ageing (EIPonAHA). Additionally, he is board member of the Foundation for Quality Assurance of E-Health (QAEH), a nonprofit foundation that aims to improve the safety of eHealth.

Sebastiaan thoroughly enjoys presenting his work and aims to have an impact in practice. So far, he has held 20+ invited presentations and his work is regularly mentioned in national and local media outlets. He is also interested in working with others to convert or translate research findings in practical tools

and approaches. Increasingly, Sebastiaan increasingly offers his services for organizations that are interested in improving the use of (health) technology. For more information on Sebastiaan and collaboration options visit www.sebastiaanpeek.nl

List of publications

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