Active DigiAge – technology acceptance by ageing people

Abstract: The ageing of society is a worldwide phenomenon, particularly in industrialised countries, like Finland. To tackle the challenges of swiftly rising healthcare and social welfare costs and a new type of demand for related services, digital assistive technology solutions have emerged in recent years. Through qualitative semi-structured interviews conducted in South Finland, this empirically driven study contributes to the understanding of the attitudes of ageing people toward digital assistive technology that maintains their activities of daily living. Empirical investigations demonstrated that ageing people cannot be treated as one homogeneous group when developing technology for them. The findings have revealed that the major moderating factors that may significantly influence older adults' acceptance and willingness to use the digital assistive technology include functional capacity, socio-demographic characteristics, digital literacy and educational background as well as the social environment supporting their ability to maintain an independent life in their own homes.

Keywords: digital assistive technology; ageing people; technology acceptance; functional capacity; socio-demographic factors; digital literacy.

1 Introduction

The changing age structure of the population with its growing number of ageing people is a worldwide phenomenon that affects industrialised countries in particular – and Finland is no exception. This has implications not only in the form of swiftly rising healthcare and social welfare costs, but also in a new type of demand for related services arising from the increase in age-related diseases and the shortage of caregivers. The current trend is shifting from a provider-dominated market to a consumer-centric market, where the end customers, senior citizens, will control their ageing and quality of life. People want to stay active longer as they age. The impact of these changes in Finland is already being felt today and is particularly acute in these times of increased pressure on public budgets and growing demands and expectations from people for equal and higher quality social welfare and healthcare services. Therefore, the need for a reform emerged, and an overhaul of the structures of the social welfare and healthcare services system has been ongoing for several years now. The objective is to not only create financially more viable bodies as service organisers, but also to achieve complete horizontal and vertical integration of social welfare and healthcare services. Another goal is to enable the ageing population to remain healthy, active and independent for as long as possible.

To tackle the challenges mentioned above, digital assistive technologies such as electronic or digital products and service solutions have emerged over the last few decades, providing innovative approaches to improving the living environment and making it easier for ageing people to carry out daily activities. Technology has the potential to support individuals in maintaining and continuing their current activities at home and in the community, as well as to improve the quality and cost-effectiveness of social welfare and healthcare services. It not only allows older adults to sustain their independence and quality of life in their own homes, but empowers them to take a more active role in managing their own health and well-being. Thus, particularly health and wellbeing assistive devices and service solutions are expected to permit ageing people to live independently in their homes longer (e.g., Niehaves and Plattfaut, 2014), reducing morbidity, social isolation and hospitalisations. In the case of Finland, adequate and effective utilisation of digital assistive technology has a major role to

play in achieving the objectives of the Finnish social welfare and healthcare (SOTE) reform. By being a part of the municipality-based social welfare and healthcare service delivery system, innovative digital technologies are also expected to bring new approaches for improving the quality of the system and creating supportive and age-friendly living environments that enable people to enjoy longer, healthier and more independent lives.

1.1 Research scope and questions

Due to widely accepted beliefs regarding the positive relation between new digital assistive technologies and quality of life as well as social welfare and healthcare services, it is increasingly important that ageing people accept these technologies and make use of them. The level of acceptance as well as the motivation to use innovative technologies will rise when people are convinced that these technologies are useful and responsive to their needs (Mitzner et al., 2010; van Dijk, 2006) and expectations. Thus, there are questions to be answered in the introduction and uptake of new technology: how to ensure that technology solutions are responsive and beneficial to the various needs, preferences and expectations of ageing people; and how to encourage the acceptance and quicker uptake of the best possible technical services appropriate to their needs.

It can be assumed that in order to maximise acceptance of new technology solutions by ageing people, these solutions should be responsive to their needs, preferences and expectations. Therefore, the importance of understanding what older people actually need to assist them in their daily activities when living independently in their own homes and how to respond to these needs is widely acknowledged in the literature (e.g., Kötteritzsch and Weyers, 2016; Mitzner et al., 2011), and is also highlighted in a recent report by the Finnish Ministry of the Environment (Ympäristöministeriö, 2017).

However, the rapid growth of the ageing population is likely to lead to a broader range of ageing people's needs, preferences and expectations that may be very deeply affected by many factors such as functional capacity, socio-demographic characteristics and digital literacy. The needs may have a positive effect on the attitude towards digital assistive technology and its acceptance in case this technology meets them. This makes it necessary to consider the influence of the above-mentioned factors on ageing people's attitudes toward digital assistive technology and its acceptance. Functional capacity comprising physical, psychological, cognitive and social functions is of critical importance, as the population ages and the number of people with weakened functional abilities increases. Socio-demographic characteristics are more complex and also play a very significant role (Flandorfer, 2012). For example, the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003) takes into consideration factors such as socio-demographic and individual factors that moderate the impact of the four key constructs on behavioural intention and use behaviour. Additionally, the impact of digital literacy must be regarded as well (Sun and Zhang, 2006), because older adults, who are digitally active and familiar with smart technologies, will be the main target group in the next 10 to 20 years.

The current research literature still lacks the information on the role these factors play in shaping attitudes towards the technology and its acceptance by ageing people. Moreover, only a small number of empirical investigations have explored the barriers and drivers affecting the acceptance and deployment of digital health and wellbeing technologies (Clark and McGee-Lennon, 2011; Heart and Kalderon, 2013). According to Niehaves and Plattfaut (2014) there are still too little comprehensive consideration and explanation of digital technology acceptance among ageing people. More empirical knowledge and thorough understanding are needed to direct the development of adequate technology solutions for ageing people and to contribute to predicting their technology acceptance.

This paper reports the results of the inductive empirical study that provide an insight into

attitudes of older adults toward digital assistive technology by exploring those factors that moderate the direct determinants of behavioural intention and use behaviour. However, the direct determinants covered, for example, by the UTAUT introduced by Venkatesh et al. (2003) are not in the scope of the study at hand. Thus, this study aims to answer the following research questions:

- How do older adults perceive digital assistive technology?
- What kind of moderating factors that influence the acceptance and use of digital assistive technologies by older adults can be identified?

The primary focus lies specifically on the digital assistive technology for active ageing that includes any digital devices, equipment or instruments and service solutions excluding assistive robotics and artificial intelligence (AI) technologies. The scope of digital assistive technology is constrained, because of the following reasons. Firstly, this technology is very extensive and has grown rapidly in the past years. Therefore, a limitation with regards to a specific group of technology was needed. Secondly, nowadays digital assistive solutions are available with a broad range of implications and are in widespread use by social welfare and healthcare services, particularly in the elder care system. However, despite the rapid technological progress and new developments in assistive robotics and AI-reliant solutions, the number of older adults using these solutions in their own homes is still relatively small.

The structure of the paper comprises the following sections. The first section offers a theoretical background of the studied phenomenon: ageing people and their attitudes towards digital assistive technologies. This continues with the introduction of the research methodology elaborating on the inductive research design, data collection and data analysis method. In the next section, the empirical findings are presented and discussed. The paper ends with conclusions, limitations and suggestions for further research to achieve the full potential of this promising new technology.

2 Theoretical background

Given that the ageing population has an impact on the elder care service system, particularly in the form of increasing demand for care personnel, societies worldwide have to find strategies and solutions for dealing with these challenges (Flandorfer, 2012; Lutz et al., 2008). It is widely acknowledged among researchers and practitioners that digital technology for assisted living can reduce the burden of healthcare and social welfare services for ageing people (e.g., Franc et al., 2011; Paré et al., 2007) and enables them to live longer independently in their own homes by offering intelligent support that helps to improve functional capacity in daily activities and health-related quality of life (e.g., Kitsiou et al., 2015; Pandor et al., 2013).

The term ‘digital assistive technology’ refers to the use of information and communication technology (ICT) to support ageing people’s activities of daily living (Olphert et al., 2009). The purpose of digital assistive technologies is to provide new opportunities for individuals to monitor and support their own health and wellbeing and to create a home environment that is safe and secure and decreases fear and stress as well as risk of disabilities or accidents, and generally supports health. In recent years, digital assistive technologies have developed rapidly augmenting traditional assistive technologies.

Nevertheless, more research is still needed to confirm the socio-economic effects of this technology in the mid- and long-term for users (e.g., Bächle et al., 2018) with further investigation on differential effectiveness between user groups and types of technologies. Moreover, there is a need to know more about the factors that may influence ageing people’s attitudes towards the wide range of digital assistive technologies already available

to them. Overall, older adults are a very heterogeneous group that include a wide range of people: from those who are healthy, active and live independently to those who are frail and need to live in nursing homes as they have degraded functional abilities. They also vary due to their socio-demographic background in terms of gender, ages, lifestyles, education level and income. Therefore, there are noteworthy differences in ageing people's needs and their attitudes towards technology (Rosenlund and Kinnunen, 2018). Previous literature has distinguished at least functional capacity, socio-demographic factors and related digital literacy level as important factors influencing technology acceptance. For a background of the study, these are opened up below, coupled with a view on user-centred technology design, which also may have a great effect on technology acceptance according to earlier research.

2.1 Functional capacity

While there is universal understanding that ageing is a very individual and inevitable process, there is as yet no common view of 'ageing' and 'old age' in the literature. This could be explained by the fact that during the last few decades, these concepts have been a point of interest in many disciplines. According to Hawthorn (2000), an 'older adult' is a person over 45, as it is in the mid-40s when the effects of ageing become visible. Alternatively, many studies of older adults start from age 60 or 65, which is the threshold of retirement age (Opalinski, 2001). For the purpose of this study, the terms 'ageing people' and 'older adults' refer to adults aged 55 years and over.

Research from the fields of adult development and life span psychology has shown that the ageing process is accompanied by a number of physical (Hedge et al., 2006), cognitive (Baltes et al., 1999), psychological (Ryff and Keyes, 1995; Ryff and Singer, 2008) and social (Bukov et al., 2002; Wilkie et al., 2016) changes. Although ageing is an individual process, these changes practically always mean a decline in functional capacity: physical, psychological, cognitive and social functions. For instance, physical functions including various elements such as muscle strength, flexibility, agility and equilibrium (Sugimoto et al., 2014) show a declining trend among all people while ageing. Decline in physical health causes challenges for the maintenance of mental health (Pynnönen, 2017).

The concept of mental health can be considered an umbrella term for psychological and social well-being (Kokko et al., 2013) as well as cognitive functioning (Pynnönen, 2017). Psychological well-being refers to six key elements: self-acceptance, positive relations with others, environmental mastery, autonomy, purpose in life, and personal growth (Ryff and Keyes, 1995). The changes in cognitive function that occur in normal human ageing involve a decline in the ability to pay attention, working memory, long-term memory, perception, speech, language, decision making, and executive control (Glisky, 2007). While some common age-related stereotypes suggest that older adults are

slower at performing many tasks and have poorer memories, other stereotypes advocate that with age comes increased knowledge and wisdom, which can be critical in solving the many complex problems of contemporary life (Park, 2000).

Social functions refer to interaction between people occurring in informal and formal contexts (Utz et al., 2002). Interaction in informal contexts includes, for example, contacts via phone, email, Skype, letters, and meetings with relatives, friends and neighbours. Interaction in formal contexts includes activities such as attending meetings of organisations or clubs, volunteer work, and religious participation. (Pynnönen, 2017) However, according to some studies, a major reason for a reduction in social participation in old age may be health problems (Bukov et al., 2002; Wilkie et al., 2016). The decline in these functions are undeniable limitations for ageing people's use of technology, particularly ease of use, and consequently may affect technology acceptance by ageing people.

2.2 Socio-demographic characteristics

Many empirical studies stress the influence of socio-demographic characteristics such as age, gender, education and technological experience on the level of technology acceptance and some of these factors can have a profound impact. However, this influence is much more complex due to the interconnectedness of these factors (Czaja et al., 2006; Flandorfer, 2012; Sun and Zhang, 2006).

As emphasised by Flandorfer (2012), stereotypes suggest that older adults are unable, afraid or unwilling to use technological devices. However, while age appears to be a key factor, it is important to point out that very limited attention has been paid to the role of age in technology acceptance research literature (Venkatesh et al., 2003).

Gender is also a very significant factor when it comes to technology acceptance. Research on gender differences shows that men are likely to be highly task-oriented (Minton and Schneider, 1980; Sun and Zhang, 2006), and seem to be motivated by the need to achieve specific goals. This can have a direct impact on how useful they perceive a technological device to be (Flandorfer, 2012). The study conducted by van Dijk (2006) uncovered that older adults' acceptance and motivation to use a technological device increase when they see the convenience of the device as well as the usefulness of its features. With regards to women's attitudes towards technology, their technology self-efficacy is estimated to be lower, which results in difficulties for them to see more clearly the benefits of using technological devices (Venkatesh and Morris, 2000). Mitzner et al. (2010) therefore emphasise the importance of convincing ageing people of the benefits they can receive from using new technologies.

Additionally, acceptance and the use of new technological devices can be significantly affected by educational background and technological experience (Czaja et al., 2006). According to Wessman et al. (2013), more highly educated people will use technology more intensively compared to lower educated ones. Further, persons who are educated and well experienced in using technology will be more eager to accept new devices, because they have the possibility to rely on their experiences (Sun and Zhang, 2006). However, older people with lower education and less experience may not have the same facility to use technical devices as more educated younger people (Czaja et al., 2006). However, it is certain that in the near future older adults will be quite different in their attitudes towards technology than those of today (Flandorfer, 2012).

2.3 Digital literacy

The term ‘digital literacy’ usually denotes a measure of the ability of users to perform tasks in digital environments and, in particular, understanding and using information in multiple formats from a wide range of sources when it is presented via computers (Jones-Kavalier and Flannigan, 2006). Digital literacy is more than just this technical ability, however. Nowadays, it has become a ‘survival skill’, which helps people to work intuitively in performing digital tasks (Eshet, 2012).

While digital literacy is the ability to develop skills in the use of new technologies (Ng, 2012) and it covers most of cognitive skills that are needed while working in digital environments (Eshet-Alkalai, 2004), it can be argued that digital literacy is also strongly related to an individual's attitude towards technology. While physical functions are of the utmost importance, they may influence digital literacy as well. Thus, considering the human ageing process and the normal degradation in people’s cognitive and physical functions, a low level of digital literacy may have a major negative effect on their attitude towards technology, whereas education background and experience of working with digital technologies may result in a higher level of digital literacy, and accordingly a positive attitude towards technology and its acceptance (e.g., Czaja et al., 2006; Sun and Zhang, 2006).

2.4 User-centred technology design and user acceptance

The growing ageing population represents a specific customer segment with significant purchasing power. While the consumption of modern digital technology by older adults is constantly increasing, this customer segment is very attractive for technology providers. In particular, for those older adults who are more digitally experienced and wish to maintain their independent living, there is a range of digital devices and service solutions that has been available on the market for a couple of decades already. Among them, the following few examples of technologies that monitor health conditions and diagnose illnesses, tele-health technologies, medication management tools and medication reminders have been developed (e.g., Qudah et al., 2010; Tang et al., 2011) and these may have an empowering impact on people's lives generally (Tuohimaa et al., 2014). For the purpose of environmental control, there are various systems that facilitate a sense of safety and independence among ageing people, using mobile emergency response systems (Eklund et al., 2005), fall detection systems (e.g., Igual et al., 2013; Stone and Skubic, 2015) and video surveillance systems (e.g., Fleck and Strasser, 2008). Other solutions provide monitoring and assistance for daily life (e.g., Suryadevara and Mukhopadhyay, 2012), enabling ageing people to remember their daily tasks (e.g., Pollack et al., 2003), as well as helping with mobility and automation (e.g., Dubowsky et al., 2000). There are also such technologies that facilitate better connection and communication of elders with their family, friends and peers (e.g., Mynatt et al., 2001), while also providing recreation and entertainment, such as interactive gaming solutions (e.g., Khoo et al., 2006; Rauterberg, 2004). Additionally, home lighting systems that continuously adapt to the psycho-physiological condition of elders according to their specific activities (Hazzam et al., 2011) are available.

Thus, older people’s acceptance of the above-mentioned technology is a necessary condition for the improvement of functional capacity in daily activities and health-related quality of life. However, in reality, a lot of problems exist in terms of the practicability of

digital assistive technologies. As Bächle et al. (2018) have shown in their recent study, there are signs that assistive technologies do not really deliver what they promise. Particularly for those older adults with a low level of digital literacy and very limited digital experience, the digital assistive technology solutions provided should be differentiated and their design should not only be user-friendly, but more user-centred as well. Technology acceptance of older users is at best facilitated by such technical solutions that really work and are designed for their special needs.

Venkatesh et al. (2004, p. 446) defined user acceptance as an "initial decision made by the individual to interact with the technology." According to the most prominent models, technology acceptance model (TAM) developed by Davis (1989) to understand expectations about information technology, two main variables have an impact on acceptance: perceived usefulness and perceived ease of use. This model has since been widely used, also in the context of digital technology use among ageing people (e.g., Niehaves and Plattfaut, 2014). However, this approach has also been criticised (Bagozzi, 2007) as it does not consider the important role moderating factors play in facilitating the acceptance and use of technology. However, another approach represented by the UTAUT (Venkatesh et al., 2003) suggests that four key constructs: performance expectancy, effort expectancy, social influence and facilitating conditions are direct determinants of behavioural intention and use behaviour. The model also takes into account moderating factors such as socio-demographic (gender and age) and individual factors (experience and voluntariness of use). However, the aforementioned models represent solely a theoretical background in the study at hand and thus were not employed as a theoretical framework for the empirical investigation of the study.

3 Methodology

The general aim of the study was a primary guideline in the choice of research methodology. It has an exploratory character pursuing to investigate, interpret and describe the research phenomenon of "ageing people's attitudes toward digital assistive technology." Therefore, a qualitative methodological approach was applied for this research, and face-to-face semi-structured interviews were chosen as the primary method of obtaining sufficiently detailed first-hand data and ensuring the co-creation of knowledge between researchers and interviewees. Interviewing is widely acknowledged to be the most effective method for uncovering and understanding the beliefs, values and behaviour of individuals (Rubin and Rubin, 2005), and it is the most commonly used method of data collection in qualitative research (King and Horrocks, 2010).

The empirical part of the study was divided into two studies: pilot study and main study. Main study consisted of two phases: main study I (individual interviews) and main study II (focus group interviews). In order to facilitate data collection in the main study phases, an understanding of the research phenomenon was needed. To this end, the pilot study was conducted with the focus on research questions and design of the appropriate interview guide for the main study I. The target groups of both studies were ageing people over the age of 55 who lived independently in their own homes. Four age groups (see Table 1) were differentiated with the purpose of revealing the differences between the 'younger' age groups (the 55–64 year olds and the 65–74 year olds) and the 'older' ones (75–84 year olds and the over 85 year olds) towards technology.

In total, ten interviews of the pilot study took place in the areas of three cities (Tampere, Hämeenlinna and Parainen) in May 2018. The interviews were planned so that there were representatives from each of four predefined age groups. From each age group with different geographical locations, at least one male (M) and one female (F) were selected, with either an academic or non-academic background (see Table 1).

Table 1 Pilot study interviewees

Age group factors	*55–64*	*65–74*	*75–84*	*85–>*
Geographical location				
Rural area	F2A	M1nA, F5nA	M2A	F1nA
Urban area	M3A, F3nA	F6nA, M4A	F4nA	

Notes: F = female; M = male; numbers 1–6 = number of interviewed person;
nA = non-academic; A = academic.

In main study I, 55 interviews were held in the South Finland area, mostly in the City of Lohja region, between May and July 2018 and were completed in October 2018. Interview participants represented all four age groups between the ages of 55 and 95 and included both females and males living independently in their own homes. Seven persons were in the age group of 55–64 years, 19 persons in the 65–74 year old age group, 19 persons in the 75–84 year old age group, and ten persons were 85 years and over. The oldest participant was a 96 year old male person. Among the 55 interview participants, only ten lived in rural areas, whereas 45 lived in urban areas. Because of the extensive urbanisation that has occurred in Finland as well as the long distances involved in travelling in rural areas, researchers had less access to people from rural areas compared to those from urban areas.

Main study II was arranged in three cities: Tampere, Hämeenlinna and Kerava, a city located in the Greater Helsinki region. The focus groups were held with older adults, who live independently in residences constructed for seniors aged 55 and over. A total of 41 older adults, including 11 from Tampere, 9 from Kerava and 21 from Hämeenlinna, participated in seven focus groups, ranging in size from 4 to 8 participants in each group. Two focus groups were conducted both in Tampere and Helsinki, and three in Hämeenlinna between November 2018 and February 2019.

Access to the participants in the pilot study phase was organised through the personal networks of the researchers in their residential areas. In main study I, interview arrangements were made with the help of students' active contacts and networks. Focus group interviews of main study II were easy to arrange through the companies, which provide different kinds of services for the inhabitants of the residence buildings designed especially for older adults. All the participants of both studies were Finns, and the interviews were conducted in Finnish.

For the interviews in the pilot study researchers created persona groups based on the interviewees' socio-demographic characteristics (age, gender, education and geographic location). The following factors regarding functional capacity were in focus while interviewing: ability or constraints in physical, psychological, cognitive or social functions. Special attention was paid to the digital literacy, which in this study, denotes digital activity meaning the ownership and active use of digital devices in everyday life.

These factors have an explanatory character, because they can help to make sense of the results of analysis and are particularly relevant with regard to ageing people.

Main study I focused on ageing people's needs, challenges and attitudes towards digital assistive technology through the lenses of socio-demographic and functional factors and digital literacy. The semi-structured interview guide was developed based on the pilot study findings. These included background questions that reflected the functional capabilities and socio-demographic characteristics of the interviewees, questions on their everyday needs and use of different kinds of digital assistive technologies, questions on the perceived benefits, risks and challenges, as well as questions on the hopes for future development. Some examples of the questions are as follows: what digital devices are you using now/used before (e.g., smart phone, tablet computer, laptop computer, personal computer, any others, none of these)?

Do you have any difficulties or needs that you think digital devices could help you with in daily life? In what ways?

A more in-depth examination of the perception and attitude of older adults towards digital assistive technology was made in main study II focusing further on moderating factors that may influence the acceptance and use of digital assistive technologies. The methodology of focus group interviewing was applied. According to Kitzinger (1995), interviews in groups exploit the inter-personal communication between all participants and group interaction to generate data. This method encouraged interviewees to talk to one another in a very open manner and was found to be appropriate for interviewing older adults in small groups. Additionally, the focus group method allowed the time available for data collection to be managed effectively. The interview guide of focus groups included questions about participants' perceptions, feelings and beliefs regarding the usefulness of digital assistive technology. Before interviewing, the purpose of the research and definitions and examples of new digital technology for assisted living were introduced to all groups.

4 Empirical findings

4.1 Findings of the pilot study

In order to analyse more thoroughly the role of the functional capacity (constraints in physical, psychological, cognitive or social functions), socio-demographic characteristics (age, gender, education and geographic location) and digital literacy of the interviewees in explaining ageing people's attitudes and decisions to accept digital assistive technology, researchers made persona descriptions. Persona descriptions were visualised in the form of persona cards (see Table 2), which illustrate the lives and experiences of people through storylines.

Persona cards reflect the major changes that occur when the population ages, namely the degradation in functional capacity and decrease in digital activity that are not dependent on geographical location. Table 2 shows that the use of digital devices was lower among the eldest interviewees, and this was mainly caused due to limitations in their functional capacity.

Table 2 Persona cards

Age group factors	*55–64*	*65–74*	*75–84*	*85–>*
Geographical location				
Rural area	F2A	M1nA, F5nA	M2A	F1nA
Urban area	M3A, F3nA	F6nA, M4A	F4nA	
Functional capacity				
Physical	F3nA	F5nA	M2A, F4nA	F1nA
Psychological				
Cognitive			F4nA	
Social				F1nA
Digital activity				
Smart phone	F2A, M3A F3nA	M1nA, F6nA, M4A	M2A	
Tablet	F2A, M3A F3nA	F6nA, M4A		
Laptop	F2A, M3A F3nA	M1nA, F6nA, M4A	M2A	
Personal computer		M4A		

Notes: F = female; M = male; numbers 1–6 = number of interviewed person;
nA = non-academic; A = academic.

However, it is noteworthy that functional capacity has a twofold influence on the use of digital technology: if the interviewees did not have many ailments, they felt that they did not yet have the need for assistive digital technology, but on the other hand, when these kinds of disabilities occurred, informants were no longer able to use the newest assistive technology. This can be seen in the following persona descriptions, for example:

> *M1nA* is a 65 year old, retired, married non-academic male person, who mostly uses a smart phone and laptop for musical activities with his band. He is not willing to broaden the use of smart devices, for instance, to the social media side or for self-monitoring in terms of wellbeing, because he has no health problems yet.

> *F5nA* is a 72 year old lady who lives with her husband in the countryside. She suffered a stroke four years ago and has been in a wheelchair ever since then due to problems in using the left side (both hand and foot) of her body. She has many physical disabilities, but socially she is active and likes spending time with her family, friends and relatives. Previously, she was an active computer user and searched for information on the internet, but after her stroke there have also been signs of slight cognitive disabilities, which seem to have had an effect also on her ability to use a computer and as a result this her computer use has decreased over the last couple of years.

Digital literacy and willingness to use technology were limited particularly among the older age informants due to decreased functional capacity as the following persona description reflects:

> *F1nA* is an 89 year old widow, living alone in her own house in the countryside. She is an artist, still painting aquarelles every now and then. She has no interest in smart devices and she has no internet connection or computer in her home. She is active in music and literature, and in summertime she is active in her garden planting flowers and other plants.

The notable finding of the pilot study is that functional capacity and socio-demographic characteristics of ageing people are not the most significant groups of factors that moderate the determinants of behavioural intention and use behaviour, but rather their general attitudes toward technology and their digital literacy. However, the findings also refer to the decreasing digital literacy among the older age groups. Additionally, worries about security and safety issues that were expressed by some interviewees might be overwhelming reasons for the limited use of the technology. Interestingly, overall, ageing people's attitudes towards digital assistive technology seemed to be mainly positive, while they were not yet very familiar with the latest devices and applications.

4.2 Findings of the main study (phases I and II)

Individual interviews in main study I revealed needs, challenges and attitudes towards digital assistive technology. Of these interviews, 55 informants were 29 older adults who reported having no difficulties or disabilities in their physical, psychological, cognitive or social health and wellbeing. On the other hand, there were 24 persons with physical difficulties like mobility and visual impairments. Altogether, 13 persons had cognitive difficulties in such areas as understanding or memorising things and instructions. Finally, five of them had psychological difficulties related to their mental health and four of them had social difficulties, such as making friends or interacting with people. Declines in functional capacity can cause tension between hopes and fears, in other words preferences for easy-to-use applications and devices can meet the competence gaps based on the fears and pitfalls of the users, as was noted also in the Pilot Study's empirical results.

In main study II, half of the 41 focus group informants had previous experience in using digital technologies, while the other half had not. In both of these groups, there were older adults who had either physical or cognitive restrictions, but only a few of them reported social or psychological disabilities. This may be explained to a large extent by the fact that all these focus group participants lived in residences for seniors, assisted by companies that provide different kinds of services for them.

In the following sections, researchers open up the key empirical findings through the quotes extracted from the interviews of the main study.

4.2.1 Functional capacity

Similarly, to the findings of the pilot study, the user's own functional capacity was brought up by many informants in different ways, as the 'two sides of the same coin' from the viewpoint of technology usage. In many cases, the functional disabilities acted as a hindrance for using digital assistive technologies. Most of the revealed difficulties and disabilities are related to physical functions, as referred to as an example in the following quote:

> "… but yes, for this old man learning to use one of these computer things has been a rocky road. I didn't need a computer in my workplace and three or four years ago I got a computer from my grandchildren… I started from scratch with it… it has been hard with these fingers."

Difficulties in physical functions were not, however, the only difficulties that hindered the use of new technology. Also, constraints related to cognitive functions, mainly in the form of challenges in understanding or memorising things, were pointed out by interview

participants, even though not in as substantial numbers as the physical difficulties. This could, however, be explained partly by the bias in the selection of interviewees; those ageing people that may have the biggest cognitive constraints were not easy to access for an interview, either.

However, in many cases, challenges in functional capacity were also a reason for using digital assistive technologies, especially when there was a decreased feeling of safety, as can be seen from the following quotes:

> "… the security side of course… This is what you feel when you get older; you think, 'What if something happens?' Even though there are some family members now or your kids who are still close by, but they don't call every day and ask you how you are doing. Yeah, that's the feeling at least now here, suddenly thinking, the most important reason."

> "So, sometimes I am afraid that… you just get a feeling that if something happens now… just like being in the corridor and not being able to open the door. And then many other things. A cell phone may be so that it can help you then. But yes, the digital safety bracelet, it seems good to me."

4.2.2 Socio-demographic factors and digital literacy

Given that the constrains in functional capacities were more common among the older age groups, empirical results reflected a decrease in the use of digital assistive technology among the older age groups. For example, within the 55–64 age group, almost everyone used a smart phone and almost half of them also used tablet computers. This reflected that the new technology is in widespread use, or has even substituted 'traditional' devices, like mobile phones without smart features, among the younger age group. On the contrary, among the oldest age group, those over 85 years of age, only a few of the interviewees used a smart phone or some other digital device. As interviews indicated, the major reasons behind the low use of digital technologies were related to different kinds of fears. The following extracts exemplify this view:

> "Yeah, that's one thing, and one of them is that such dangerous-looking devices where those things flicker, so we can't be sure if our own information goes somewhere in the wrong place, it's the fear of these devices a little… it is probably for the most of us, it's the fear of using devices and programs."

> "Then there come all the times different updates to the tablet due to different programs. And then you think about updating or not updating. If you are going to upgrade, then there always come additional questions. And then there are the problems again."

> "We do not have special needs for digital technology, but a lot of hesitation: Can we learn to use them?"

The presence of fears towards the use of technology can partly be explained by the lower level digital literacy particularly among older age groups. Informants often expressed their fears regarding the use of technology due to absence of technical knowledge and skills in performing digital tasks. These fears make older adults' attitudes towards the acceptance and use of technology more negative. There were also other signs of lower digital literacy level, as can be seen in the following quotes:

> "There are people who are technical, and others who are less technical, and they are somewhere else better. For example, I can tell that I am not a technical person. My husband was a technical person and learnt technological things fast,

> it was clear to him, and when I tried, he could hear a little bit of trouble. He knew I wasn't that fast. I needed a lot more time to understand it. I don't trust myself because it's not so clear to me. But then when you find out that you have done it more than once, it will stay there."
>
> "Bluetooth, yes… but how to connect to it? And then, there was a bit of cable in it, and then at the other end there was something strange. And then I asked what should I do?"

On the contrary, the representatives of younger age groups with a higher level of digital literacy expressed more fears, for example, about the security of personal data storage in the future. They recognise the risks related to the health databases and acknowledge them as a real threat.

> "In whose hands is it, who can manipulate it, who can exploit it, how is it secured – these are the big questions."
>
> "However, the risks are increasing all the time, and this kind of [health] information, if any is available, it is possible to sell."

In addition, these older adults are very active in using the internet to search for information regarding new digital technology:

> "We go look for it there [on the internet], we Google it and see what kinds of reviews there are for the equipment, and based on that we then choose something that's average or good."
>
> "Information is available over there… these private individuals who then give their own critiques about some specific device… meagre user experiences, but they are based on facts. So, we do kind of check a bit of everything… on the net forums."

Interviews also revealed that educational background plays a significant role in explaining older adults' willingness to accept and use assistive technology in everyday life. In our study, all interviewees who did not have any digital devices in use and accordingly possess non-existent digital literacy were only educated to the primary school level.

> "It's a difficult question, of course, if you are talking about a device now."
>
> "It's in that smart phone, and they are for smart people. And when one day you learn it, you will forget in no time! Forget, yeah [laughing]."

Regarding the digital literacy of ageing people from rural areas, interviews indicated that they are rather old-fashioned when it comes to using digital devices compared to those living in urban areas. For example, not one of those interviewed who lived in a rural area had a smart phone. This can be considered as a sign of the differences in digital literacy between people living in rural and urban areas. However, we cannot generalise this finding due to the limited number of older adults from rural areas who participated in the research.

4.2.3 Supportive social environment

A few of the people interviewed were identified as having some social difficulties, such as making friends or interacting with people. A decrease in social functions may hinder the acceptance and use of technology, as it makes it harder to get help and encouragement in using the digital technology. In practice, older adults tend to count a lot on the

encouragement and support of their friends, close family members and relatives regarding the use of digital technology. However, a lack of support was also mentioned by some ageing people that had close family relations. In some cases, the interviewees even wanted to nurture their social relationships by not asking any help for technology as the advice giving was perceived as a burden:

> "I do not want to learn digital technology, because both the person teaching me and I would get angry, when there was no progress in my studies."

Those older adults who represent younger age groups and possess a higher level of digital literacy are not likely to rely only on their friends and relatives' opinion but on very practical and technical things:

> "… whole family, your immediate relatives and those relatives, who live a bit further away, the communication that you need with them is vital. So, compatibility of communication devices among, like, your inner circle is a pretty essential criterion."

Interestingly, in some cases close relationships with family members may also decrease the need for using technology especially among people of older age groups. The following quote illustrates this view point:

> "Well, why should I use any devices as long as I can get personal help and services…? My children can use the devices and they can help me when needed, for example, with internet banking."

5 Discussion and conclusions

This study shed more light on the perceptions and attitudes of ageing people towards digital assistive technology and their willingness to accept it, by answering the research questions: *How do older adults perceive digital assistive technology? What kind of moderating factors that influence the acceptance and use of digital assistive technologies by older adults can be identified?* By analysing empirical data collected thought interviews with 96 older adults in South Finland, this qualitative study extended the existing knowledge about the most significant moderating factors and their role in explaining older adults' attitudes towards digital assistive technology.

The findings have revealed that in the context of ageing people, the major groups of factors that may influence their behavioural intention and use behaviour include functional capacity and a social environment that supports an independent life in their own homes regardless of the age groups predefined for this study. The findings showed that also socio-demographic characteristics such as age, gender, education background and geographical location play a special role in ageing people's attitude formation. However, researchers observed no definitive differences in the attitudes towards technology between genders and the predefined age groups, except the fact that persons representing older groups were more worried about their functional capacity and digital literacy needed to use technology. On the contrary, there were noticeable differences in the attitudes with regard to ageing people's educational background and working experience.

Additionally, digital literacy, which is closely related to educational background, was found to be a notable moderating factor that may have a significant impact on the attitude

towards new technology. In compliance with this finding, it is important to stress the significance of both digital literacy and educational background and to suggest the incorporating of them in addition to functional capacity into the acceptance and use of technology model (UTAUT). These moderating factors will improve the model's specificity and utility particularly in the context of older technology users and increase the potential for better predicting of their behavioural intention to use new technology.

Furthermore, findings have indicated that older adults living in urban areas possess more positive and curious attitudes towards technological solutions and are more motivated to learn how to use them than the ones living in rural areas. However, the attitudes of ageing people living in urban areas are not homogeneous and may notably vary also due to differences between larger and smaller communities. For example, larger communities may have more resources to support older adults in their daily life needs, but on the other hand, in smaller communities they may receive more personal social support services. In this relation, it is important to denote that in many cases, ageing people's daily life needs, preferences and expectations may have a more powerful influence on their attitude towards technology than identified moderating factors. Irrespective of living area, when older adults understood that their needs could be fulfilled using technological solutions, they felt more positively about the technology and showed willingness to use it.

It is also important to stress the straightforward message received from the interviewees of this study. It concerned the needs of older adults for training and technical support that should be equally available for everyone in case of problems while using technological devices. In addition, a more integral involvement and support from social care providers and family members in learning new technologies was acknowledged as very significant. This leads to a conclusion that cooperation among the stakeholders of the elder care system and technology producers in providing support is critical for ageing people's positive attitudes towards technology and its acceptance and the quicker uptake of the best possible solutions among older adults. However, this creates a major challenge: how to organise and coordinate the cooperation in practice. Moreover, this not only requires the effective continuous technical training of social service providers and the involvement of technology providers, but also a deeper integration of digital technology solutions into the system of social welfare and healthcare services. This finding is well in line with the work of Bächle et al. (2018) who addressed the lack of knowledge regarding the design of social systems around assistive technologies.

Considering the findings of this empirical study, the following future research areas can be proposed. Firstly, cooperation between all the stakeholders of the elder care system and technology producers would benefit also from more evident empirical research results proposed by researchers from different disciplines. Secondly, the introduction of the benefits of new technology solutions could also be enhanced by research that would bring up more clearly the multiple ways that assistive digital technology has created value in real-life cases. Thirdly, there is a need for research on how to apply better user-friendly and user-centred technology design principles in R&D that would benefit producers in better fulfilling the needs of the older customer segment.

Two major limitations should be acknowledged in regard to this study. First, the generalisability of the findings is limited as the number of participants from rural areas was not representative, and caution should also be taken when making too broad interpretations in comparison of data collected from people living in urban and rural areas

and argumentations about the differences in their attitudes towards technology. Another limitation that needs to be considered is that attitudes towards technology were operationalised in the context of digital assistive technology having not specified any particular technological services or products. These limitations also raise avenues for further research. In order to produce more rigorous results, future research should be better extended to rural areas and have a specific type of digital assistive technology in focus. Older-user experience as well as family members experience pilots should be an essential part of further research.

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