Human–Centered Design of E–Health Technologies: Concepts, Methods and Applications

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ABSTRACT

Facing the growing aging population in many countries of the world, healthcare-related technologies become increasingly important, representing a possible solution to the soaring overstrained health care systems and dwindling number of caregivers. Though, a user-centred and sensible integration of medical technology in home environments is highly challenging, especially when focusing on the group of old and frail users. Their specific needs and wants, their (dis)abilities and limitations have to be carefully considered, in order to reach full acceptance and a successful rollout of e-health applications in home environments. As the knowledge about acceptance in the medical sector is still limited, an elaborate research is needed in order to understand and respect aged persons’ specific demands. In an empirical approach, the role of age, technology generation, technical expertise, and gender are determined for the acceptance of medical technologies. As the acceptance of medical technologies might be also biased by social norms and the way aging and age-related consequences are evaluated within a society, individual ageing concepts as well as economic and educational levels were considered for the evaluation of the perceived benefits and drawbacks of medical technologies. Outcomes show the importance of understanding of users’ needs and wants in order to develop user-centred medical technology concepts and to allow a successful rollout.

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INTRODUCTION

In the last few years, an increasing public awareness regarding the consequences of the demographic change can be observed in many countries, which is imposing considerable challenges on future health care systems in the next decades. Drastically demographic changes and such aspects as increased life expectancy, improved medical healthcare, reduced fertility rates, will lead to a growing number of frail older people, who will need medical treatments and long-term care provided by official health care systems (Leonhardt, 2006). One of the central challenges for political and health care systems in the 21st century is therefore to master the demands of an aging society (Arning & Ziefle, 2009a; Rogers, 2009; Stronge et al., 2007).

Electronic health technologies will play an increasingly important role in the coming years, as more and more older people will require medical care and support (Leonhardt, 2006; Warren & Craft, 1999; Weeks et al., 2005; Wyeth et al., 2001). There is an increased need for intelligent medical technologies, which enable people to live independently at home (Czaja et al., 2008; Holzinger et al., 2010; Kleinberger et al., 2007; Ziefle & Röcker, 2010). Electronic healthcare technologies support the interaction between patients and health service providers, institution-to-institution transmission of data, and peer-to-peer communication between patients and health professionals (Arning & Ziefle, 2009b; Gaul & Ziefle, 2009).

Within the last years, a variety of new healthcare concepts for supporting and assisting users in technology-enhanced home environments emerged (Klack et al., 2010; Meyer & Mollenkopf, 2003; Ziefle & Röcker, 2010). These so-called Ambient Assisted Living (AAL) applications are characterized by a combined use of information and communication technologies and health monitoring devices in the home domain. Mobile technologies in combination with ambient technologies offer enormous potential to improve patients’ medical care and reduce the financial pressure on health care systems alongside progress in biomedical sciences or genetics. The spectrum of emerging technical applications covers a broad variety of developments, reaching from internal technologies (implants for monitoring physiological signals) over devices integrated into clothes (wearable technologies) to healthcare robots or smart home technologies, which support older people in keeping up their independent life at home (Kasugai et al., 2010; Gaul & Ziefle, 2009; Demiris et al., 2008; Meyer & Mollenkopf, 2003; Schmitt, 2002).

Supporting older patients in keeping mobility and maintaining an independent lifestyle at home will only be achievable by systems, which fulfill certain criteria. Such systems are supposed to monitor and control health-related information, are portable and communicable, and fit into the ecology of existing mobile devices as well as Ambient Assistant Living (Ziefle et al., in press).

These innovative smart health care technologies promise to deliver significant improvements in access to care, quality of care, and the efficiency of the health sector (Leonhardt, 2006; Meyer & Mollenkopf, 2003; Mynatt et al., 2004). Though, the development in medical technology is impressive, nevertheless, practical experience shows that the brilliance and novelty of technical solutions does not guarantee the successful diffusion of these innovations. In order to reach a high degree of user acceptance, not only the technical and engineering parts are of importance, but also the human aspects of these technologies and the way how they meet user’s wants and needs regarding privacy, dignity, and their requirements for as useful perceived medical technologies (Lahlou, 2008; Necheles, 1982; Ziefle & Wilkowska, 2010; Zimmer & Chappell, 1999). Thus, the success of (future) healthcare technologies depends decisively on the extent to which technical developments meet the specific needs and demands of users, and on their willingness to use and integrate devices into their personal spaces (Gaul & Ziefle, 2009; Ziefle &
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Wilkowska, 2010). One should be aware that these technologies fundamentally change the nature of social, economic and communicative pathways. Communication and information are ubiquitous and overcome physical as well as mental borders. Sensitive and detailed information regarding persons’ health states and physical conditions are available everywhere and at any time. Within the public awareness, and especially for old and frail seniors, which only have little contact with new technologies, these developments may implicate both, positive (productivity, mobility and growth) and negative or even threatening effects (violations of privacy, security concerns, infrastructure constraints and distrust in smart medical applications).

So far, research on medical technology is mostly dominated by technical, medical and economic disciplines. The same applies for developments of medical products, which are predominately guided by medical necessity, technical feasibility, as well as legal matters and economic interests. In contrast, aspects of humans’ technology acceptance as well as the detailed study and the willingness of understanding individual usage motives and barriers are mostly disregarded, or even underestimated within technical development so far. Though, medical technology – especially in the home care and rehabilitation sector – can only fully deploy its huge potential for graying societies, if acceptance issues of medical applications are adequately considered and addressed. Usable interfaces, a full acceptance and a broad understanding of these technologies as well as slick user experience will be critical success factors for acceptance, sustainability and competitive capacity of any technical system.

BACKGROUND

When looking on the mentioned success criteria we observe that currently neither of these is fulfilled. Still, the development of technology seems to be limited to primarily young, technology experienced, western, middle- and upper class males (Shneiderman 2000; Rogers, 2009; Ziefle & Jakobs, 2010). Although the vital importance of ensuring that the technology produced is both usable and appropriate for diverse user groups, recognition of the importance of diversity is only slowly influencing mainstream usability studies. Design approaches have thus to undergo a radical change taking current societal trends, which have considerable impact for the inclusion of diverse user groups, into account.

User Diversity

A first factor in this context is the user diversity. Individual differences, such as demographic variables, computer experience, cognitive abilities and personality factors have long been important in end user computing research (Zmud, 1979). It was found that individual differences are significant factors in explaining both technology acceptance and user behavior (Arning & Ziefle, 2007a; 2009a; Chua, Chen, & Wong, 1999; Gefen & Straub, 1997; Harrison & Rainer, 1992; Sato et al., 2006). In the context of this study we refer to a key set of variables like age and technology generation, but also computer expertise and gender.

The factor age plays an important role in the explanation of variability in system acceptance and performance. Though, the design of age-sensitive interfaces is a highly challenging task, because the process of aging itself is extremely differential and complex. Not all users age in the same way, as the onset of ageing processes and the affected cognitive abilities and functions show considerable interindividual differences (Freudenthal, 2001; Ellis & Allaire, 1999; Lin, 2001; Ziefle & Bay, 2005; Craik & Salthouse, 1992).

With respect to effects of users’ age on performance when interacting with technical devices, previous studies congruently showed that older users usually have greater difficulties in handling a computer device or in the acquisition of computer skills (Arning & Ziefle, 2007a, b; 2008; Goodman
et al., 2004; Ziefle, 2002; Marquie et al., 2002). Also, older users face difficulties in learning and using new computer applications (Arning & Ziefle, 2010; Selwyn et al., 2003). The profound changes in sensory, physical, psychomotor and cognitive functioning over the life span (Fisk & Rogers, 1997; Rogers, 2009) may account for older adults’ lower performance when using technical devices. In this context it is insightful to understand that age is only a “carrier” of specific abilities and attitudes. It is therefore useful to consider age in the context of technology generation (Sackmann & Weymann, 1994), referring to the different upbringing of individuals and the different technology types, which were predominant in the respective time and to which older adults were accustomed during their education. Sackman & Weymann (1994) differentiate three technology generations, and age groups, the early-technical generation (65+ years), the household revolution generation (49+ years), and the computer generation (26+ years). Of course, as the mentioned research stems from 1994, the age categories have to be adapted to actual measures.

Another factor that is likely to severely influence older adults’ performance and acceptance of technology is that aged users were educated in times when technical products were far less ubiquitous and much less complex than current devices. A mental model of how technology works, built in a former time, potentially interferes with, or at least is not sufficient for proper interaction with technology (Ziefle & Bay, 2004). As a consequence, the previous experience is also decisive for satisfying acceptance of devices. This fact is aggravating the situation especially for seniors, as the understanding of how technology works is to a large extent formed by upbringing and cultural factors. Contrary to current stereotypes, according to which older users are unable or unwilling to learn new technologies, they are indeed interested to become acquainted with it. However, they do have higher demands on usable interface designs (Arning & Ziefle, 2006; Tuomainen & Haapanen, 2003; Ziefle & Bay, 2008; Ziefle, 2010a, b).

Up to now, HCI designs are often realized without considering the abilities and needs of this user group. Zajicek and Hall (2000) state that perceived usefulness of a technology is lower in older adults, because they weigh the perceived usefulness against the time to learn how to operate the system. Related to this balancing procedure is the fear of failure as additional cost, which is much more pronounced in older adults (Wilkowska & Ziefle, 2009a; Melenhorst et al., 2001; 2006).

Another influential factor of menu navigation performance is computer expertise (Ziefle 2002; Downing et al., 2005; Levine & Donitsa-Schmidt, 1998; Morrow et al., 2002). Generally it was found that experts show a superior performance with respect to the utilization of technology. Computer experts reach a higher effectiveness and efficiency in menu navigation performance, because highly organized knowledge structures and a deeper system understanding lead to a detailed perception of problems, to flexible problem solutions, and to an efficient usage of short- and long-term memory functions (Marquie et al., 2002). As a matter of fact, older adults are mostly less experienced in computer usage and have lower technical understanding. As a result, the majority of older adults possess limited computer knowledge about how to operate technical devices (Evans & Simkin, 1989). Those age-related changes may increase the difficulty of computer-related tasks and may therefore account for differences in computer-based performance (Czaja & Sharit, 1998).

Besides cognitive variables, personal characteristics like self-efficacy are able to explain performance variability. Computer self-efficacy refers to the individual confidence in one’s capability to use technical devices. Studies have shown that high scores in computer self-efficacy are related to navigational performance and the reported ease of use (Arning and Ziefle, 2007a; 2008; 2010).
Although gender differences have been missing for a long time in IT research, they are now widely discussed as an important factor in the explanation of computer attitudes and performance. In the TAM (Davis, 1989) no references to the impact of gender are found. On the other hand research has shown that women usually report lower levels of computer-related self-efficacy and a higher computer anxiety (e.g., Busch, 1995; Ziefle & Schaar, 2011) as well as a lower subjective technical confidence when using technical devices (Wilkowska & Ziefle, 2009a; Arning & Ziefle, 2007a; Beier, 1999; Ziefle et al., 2007). Even though women’s attitudes towards technology are more negative and their self-confidence when using technical devices is significantly lower, gender effects seem to be limited to attitudes and subjective measures, and do not involve lower performance outcomes for female users (e.g., Arning & Ziefle, 2007a, b; Brosnan, 1998; Czaja & Sharit, 1998; Evans & Simkin, 1989; Ziefle & Bay, 2006). This shows – once more – that the relationship between individual variables, attitudes and performance requires further examination.

**Technology Acceptance**

A second factor relates to the concept of technology acceptance, which does not meet the sophisticated requirements of todays’ medical technologies in the home sector any more.

The majority of approaches dealing with technology acceptance refer to the acceptance of information and communication technologies (ICT) (Adams et al., 1992; Davis, 1989; Szajna, 1996; Venkatesh et al., 2003; Venkatesh & Davis, 1996; 2000). Theories of technology acceptance consider mainly two key components: the perceived usefulness of a technical device and the perceived ease of use as determinants of individuals’ intention to use a technical system (e.g., Technology Acceptance Model, TAM, Davis, 1989). However, one of the main criticisms of these models was that external factors such as the influence of individual user variables on technology acceptance were almost completely disregarded. The most recent development within acceptance modeling represents the UTAUT model (Unified Theory of Acceptance and Usage of Technology, Venkatesh et al., 2003), which assumes performance expectancy, effort expectancy, social influence, and facilitating conditions as key constructs for technology usage intention and behavior. Additionally, individual variables are assumed to mediate the impact of those constructs on usage intention and behavior. Yet, only few studies concentrated on the diversity of users and their acceptance patterns (Gaul & Ziefle, 2009; Wilkowska & Ziefle, 2009a; Arning & Ziefle, 2007a), even though it is clear from daily life experience that people may have different adoption behaviors due to individual characteristics (age, gender, culture, abilities, beliefs). Still more important, there is only little knowledge, in which respect and to which extent the type of technology (invasive vs. non-invasive, visible vs. invisible) impacts acceptance patterns (Ziefle & Schaar, 2011; Wilkowska et al., 2010; Ziefle et al., 2011). If we want to learn the impact of technology adoption as well as its consequences for persons’ social lives, a deeper understanding of technology acceptance is needed. Yet, hardly any study so far considered the impact of social factors on the acceptance of medical technologies in the older user group. This especially regards socioeconomic factors (financial situation and degrees of freedom, living conditions) but also individual ageing concepts, which surely do influence the using motivation of medical technologies in home environments.

Another, in the here addressed context, problematic characteristic of existing technology acceptance models is that approaches exclusively focus on acceptance patterns of ICT, and they are predominantly job-related. A direct transfer of their assumptions to the acceptance of medical technology is highly disputable, though, this has not been fully analyzed yet. Up to now, only a few existing studies investigated the special nature of
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acceptance regarding medical technology (Ziefle & Wilkowska, 2010; Arning & Ziefle 2009b; Gaul et al., 2009; Ziefle & Schaar, in press; Wilkowska et al., 2010; Ziefle et al., 2010). However, it is quite reasonable to assume that the acceptance of medical technology distinctly differs from acceptance-patterns of other technologies, which are widespread within our societies. First, medical devices are used not just for fun but especially for (critical) health states. Also, beyond its importance for patients’ safety and the feeling of being safe, medical technology refers to “taboo-related” areas, which are associated with disease, and illness (Gaul et al., 2009; Ziefle & Schaar, in press). Second, recent studies show that medical monitoring is often perceived as breaking into persons’ intimacy and privacy spheres and often lead to a feeling of being permanently controlled (Ziefle & Wilkowska, 2010; Ziefle & Schaar, in press).

The acceptance for medical technology is highly complex torn between a lot of perceived benefits and serious concerns, driven by individual and situational aspects, especially when focusing on medical technologies that enter the body (invasive technologies). We therefore conceptualize acceptance as a “product” based on individual usage motivations (using motives as well as perceived barriers) and situation-specific evaluations, driven by individual needs and wants. Also it is reasonably to assume that the diversity of users is critically impacting acceptance and the extent to which technology is perceived as respecting feelings of intimacy and dignity, and the extent to which health technologies provoke feelings of trust, respect, and safety.

MAIN FOCUS OF THE STUDY, QUESTIONS ADDRESSED, AND LOGIC OF EMPIRICAL APPROACH

The integration of future medical technology in home environments is a high contemporary issue, which requests a high willingness of users to accept new forms of medical assistance and to rely on technology in a very sensitive and intimate field. In this study, an exploratory approach is presented, which aims at understanding acceptance of medical technologies against the background of user diversity. The main focus was directed to the (anticipatory) usage of medical devices and to a detailed analysis of possible factors influencing it. In order to comprehend user diversity, younger, middle-aged and older adults were examined, as well as the impact of gender. Additionally, the moderating influence of education and financial status were explored. Beside the effects of users’ characteristics on usage of medical technology, analyses of influence on technical learning history and on some ageing concepts were conducted. Moreover, the motives pro and against usage of technologies (IC- and medical technology) as well as connections between them were studied.

Research Model and Hypotheses

As the current paper aims to find out in explorative way, which factors influence acceptance and usage of medical technologies in future home environments and how – or rather how strong – users’ characteristics are connected in this regard, a user-centered approach was pursued, which considered the characteristics and attitudes of a highly heterogeneous user group. Assumed, that medical assistance devices are predominantly needed and used by older people it is of great interest to observe, how participants in this group perceive the usage of medical technology, and to compare these results to the (anticipatory) usage of younger aged persons. It is moreover relevant to learn, if, and to which extent the usage willingness applies to both sexes, and how it is connected to the educational level and financial status of respondents.

We assume that the real motives for the usage of medical assistance are influenced by different factors. On the one hand, they are related to perceived advantages and gains (pro-arguments), which
support the positive attitude towards medical technology and the willingness to use healthcare devices. On the other hand, perceived disadvantages and resultant barriers (contra-arguments) can also overshadow the usage, and may provoke averseness to use and accept it, as a consequence. Also, it is an interesting question, how the motives pro and contra the usage are connected with each other, and how they are associated with respect to different technologies (ICT vs. medical).

Additionally, an encouragement and motivation to use medical technologies are most likely related to peoples’ technical learning history with common information and communication devices. It is conceivable, that – apart from the possible exigency to use medical assistance – a frequent and untroubled interaction with ICT results in increased technical self-confidence, and enhances the willingness to use healthcare devices (e.g., blood pressure meter for a preventive inspection). On the contrary, experienced difficulties and pitfalls in daily handling of ICT-utensils may cause technical disrelish and the feeling of technical incompetence, which rather weakens the motivation to use medical utensils. We moreover assume, that with increasing age of users, the technical experience decreases, i.e. younger users are – due to their different upbringing and their frequent contact with modern ICT-devices – more technical experienced than older users, which influence the willingness of using medical technology, too. For this reason we differentiate three technology generations following the model of technology generation from Sackmann and Weymann (1994), in which they distinguished between the early-technical generation, the household revolution generation, and the computer generation.

We investigate furthermore, if different ageing concepts (which are described in the following more precisely) are reflected in attitudes and viewpoints regarding usage and integration of (future) medical technology in home environments.

How do we intend to tie up all those factors in this study shows our research model (Figure 1). Thus, in our research model we examined the influence and connection of diverse users’ characteristics with medical technology usage. According to the proposed model following hypotheses are specified:

- **H1:** Individual factors, such as age and gender, impact respondents’ ageing concepts, which are connected with usage of medical technology.
- **H2:** Individual factors affect users’ technical learning history as well as their motives to use common ICT-devices.
- **H3:** Persons with a high motivation to use information and communication technologies show also a positive attitude towards usage of medical technology, and analogue, people with high attitude against ICT usage show correspondent barriers to use medical assistance.
- **H4:** Individual factors have an important effect on an attitude towards and willingness to use medical technology, and they determine user’s motives and barriers to use it.

**Method**

In order to collect comprehensive opinions and to reflect them across a broader sample of women and men of different ages, we chose the questionnaire-method. In this section we introduce the procedure of the exploratory approach, including a description of the questionnaire instrument, the questions asked in order to collect the different topics under study as well as the sample, which volunteered to take part in this study.

**The Questionnaire**

The questionnaire used in this study was developed in order to examine a large number of participants and to collect their comprehensive opinions considering the diversity of age, gender, education and...
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Figure 1. Research model

![Research model diagram]

financial status. Its structure in terms of contents included – beside demographic data – three main subject areas. One is the ageing concept, which implies conceptions regarding quality of life, estimated misgivings as well as active and passive attitudes towards ageing. Some of the used items are exemplified in Table 1.

Table 1. Questionnaire examples and used scales regarding ageing concepts

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Example-Items</th>
<th>Scale</th>
</tr>
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</table>
| Life quality        | “Life quality is…  
- to be able to fend for oneself.”  
- to have a persistent social network.”                                                                                                           | from ‘totally important’ to ‘not important at all’  
6-point Likert-scale |
| Estimated misgivings| “Being aged I’m afraid, that …  
- because of health-impairments my activities would be rather limited.”  
- I’ll become a burden for others (e.g., my children).”                                                                                         | from ‘totally agree’ to ‘totally disagree’  
6-point Likert-scale |
| Active attitude     | “I’m sure, that my state of health also at older age can be maintained with healthy nutrition and fitness.”  
“I believe that due to my higher experience of life, I can be very utile to my family and to the society, when I’m older aged.”  | from ‘totally agree’ to ‘totally disagree’  
6-point Likert-scale |
| Passive attitude    | “I believe, that at older age because of the increasing impairment my mental performance will decrease continuously.”  
“Being older aged means to me being weaker and frailer, and I don’t believe that I can do anything against it.” | from ‘totally agree’ to ‘totally disagree’  
6-point Likert-scale |
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The second subject area pertains to person’s technical learning history including the technical experience, i.e. the usage frequency and perceived degree of navigating difficulty of common ICT devices (such as personal computer/notebook, mobile phone, video/digital camera and DVD-player), as well as the subjective technical self-confidence when handling them. In addition, the motives pro or against the ICT usage in terms of pro- and contra-arguments is assessed in this regard. Table 2 represents exemplary survey items in this context.

The third and final part of the questionnaire refers to medical technology and surveys user’s anticipated benefits and disadvantages (pro and cons), as well as general attitude towards and the willingness to its usage. Additionally, assessment criteria for buying and using ICT- and medical devices were enquired. Table 3 includes some item-examples for each built dimension in this regard.

Before administering the questionnaire it was revised by a sample of different aged adults (n = 12) and by a usability expert with respect to issues of comprehensibility and wording of items. The fill in of the final version of the questionnaire took 20-30 minutes.

Table 2. Questionnaire examples and used scales regarding technical learning history

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Example-Items</th>
<th>Scale</th>
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</thead>
<tbody>
<tr>
<td>Technical experience</td>
<td>“The handling of technical devices (PC, cell phone, etc) is…”</td>
<td>from ‘very easy’ to ‘very difficult’</td>
</tr>
<tr>
<td></td>
<td>“How frequent do you use in your daily life…”</td>
<td>from ‘every day’ to ‘never’</td>
</tr>
<tr>
<td></td>
<td>- personal computer/notebook</td>
<td>both 6-point Likert-scales</td>
</tr>
<tr>
<td></td>
<td>- cell phone, etc.</td>
<td></td>
</tr>
<tr>
<td>Subjective technical confidence</td>
<td>&quot;Usually, I cope with technical problems successfully&quot;.</td>
<td>from ‘totally agree’ to ‘totally disagree’</td>
</tr>
<tr>
<td>(STC)</td>
<td>“Technical devices are for me inscrutable and unmanageable”.</td>
<td>6-point Likert-scale</td>
</tr>
<tr>
<td>ICT pro-arguments</td>
<td>“It is fun for me to manage a technical device.”</td>
<td>from ‘totally agree’ to ‘totally disagree’</td>
</tr>
<tr>
<td></td>
<td>“I’m very interested in technical devices.”</td>
<td>6-point Likert-scale</td>
</tr>
<tr>
<td>ICT contra-arguments</td>
<td>“Nowadays technical devices congest the market.” “I believe that a person can rather help me than a technical device.” “These days there is too much dependency from technologies in our society”.</td>
<td>from ‘totally agree’ to ‘totally disagree’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-point Likert-scale</td>
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</tbody>
</table>

Table 3. Questionnaire examples and used scales regarding medical technology

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Example-Items</th>
<th>Scale</th>
</tr>
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<tbody>
<tr>
<td>Attitude towards MT</td>
<td>“Medical devices provide an insight into my health status.”</td>
<td>from ‘I fully agree’ to ‘I don’t agree’</td>
</tr>
<tr>
<td></td>
<td>“Medical devices enable older or diseased people to be longer independent from health care facilities.”</td>
<td>5-point Likert-scale</td>
</tr>
<tr>
<td>(Anticipatory) Willingness to use MT</td>
<td>“I would rather use medical assistance technology than become burden to my family.” “I would use medical assistance technology when it assures that I can stay in the privacy of my home.”</td>
<td>from ‘I fully agree’ to ‘I don’t agree’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-point Likert-scale</td>
</tr>
<tr>
<td>MT pro-arguments</td>
<td>“I would use MT for storing my health-related data (e.g., blood pressure measures) for better information about my health status.” “I would use MT and storage my health-related data because in case of emergency it is beneficial for the doctor/physician.”</td>
<td>from ‘I fully agree’ to ‘I don’t agree’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-point Likert-scale</td>
</tr>
<tr>
<td>MT contra-arguments</td>
<td>“I wouldn’t use MT because I don’t want to feel dependent from any technology.” “I wouldn’t use MT because I don’t trust in the reliability of the technology.”</td>
<td>from ‘I fully agree’ to ‘I don’t agree’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5-point Likert-scale</td>
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</tbody>
</table>
The Sample

The data of N = 122 voluntarily respondents at the age between 20 and 80 years (46% female) were collected and analyzed in this study. The sample was divided into three age groups, and technology generations, respectively:

- The first group was aged between 20 and 35 years and consisted of 43 persons (M = 29, SD = 3.9; 40% females, 60% males).
- The second age group (n = 41) was composed of males (44%) and females (65%) at the age between 36 and 54 years (M = 45.4, SD = 5.3).
- The third age group contained 38 respondents between 55 and 80 years old (M = 64.3, SD = 6.9) with the proportion of 42% females and 58% males.

The recruitment of respondents aimed at differently aged but healthy persons in order to explore and to compare their ageing conceptions as well as their technical learning history having regard to opinions about (future) electronic healthcare solutions as well as their intended usage behavior in home environments. The participants were reached on different ways. Most of the younger respondents were university students of various academic fields (technical disciplines, social sciences, and humanities), but there were also persons being currently in vocational trainings or serving an apprenticeship (electricians, insurance salesman, bakers). The middle-aged and older respondents were reached partially by advertisements in a local newspaper and partially through the social network of the authors, but also through seniors’ social contacts; they all covered a broad range of professions and educational levels (e.g., healthcare workers, administrative officers, teachers, secretaries, accountants, nurses, engineers, physicians). Also financial status of participants was collected in order to scan possible moderating role of this factor in usage and attitude towards technologies. Thereby, 35% of the reduced sample – we received the information about the income per year from n = 122 respondents – specified their earnings < 20,000 Euro, other 42% reported their income as < 40,000 Euro, 19% indicated their annual salary as < 70,000 Euro, and the remaining 4% of respondents marked their yearly income as > 70,000 Euro.

Results

The results of this study were analyzed by bivariate correlations, multivariate and univariate analyses of variance with a level of significance set at 5%. Outcomes within less restrictive significance level of 10% are referred as marginally significant. The significance of omnibus F-Tests in (M)ANOVA-analyses was taken from Pillai values. Mean value differences were analyzed with T-test.

The influence of the factors age and gender was assessed for all analyses, and the moderating influence of educational level and financial status were added as covariates into the analyses.

The result section is composed of following reference fields: at first, the impact of user diversity on respondents ageing concepts is tested; with the next step users’ learning history assessed as the sum of frequency of usage of popular ICT devices, and the perceived level of difficulty while handling them was analyzed; additionally, the influence of users’ characteristics on subjective technical confidence as well as on their motives and barriers in terms of pro- and contra-arguments were examined in this part of the result section. Moreover, participants’ general attitude towards and (anticipatory) willingness of using medical technology were explored; thereby – analogical to ICT analysis – users’ motives pro and arguments against usage of medical devices were checked up. In addition, assessment criteria in terms of degree of relevance were compared for common used and medical devices and the most important criteria in both technologies were identified. Finally, a revisal
of research model as well as detailed interrelation of variables used in this study is presented.

**Ageing Concepts and User Diversity**

**Perceived Quality of Life at Older Age**

In order to explore if peoples’ ideas of ageing have dealings with (future) usage of medical technologies, different measurements in this field were assessed. In the first place the respondents had to rate, as how relevant they consider different aspects for a good quality of life when being older aged. In one case everybody – whether younger or older, whether female or male – seem to agree about the desire to live in the own four walls when old, reaching a mean of 4.9 (SD = 1.5) out of maximum of 6 points (‘very important’). This finding shows that independency at home is neither age nor gender-sensitive, but represents a unique attitude across persons, at least in Germany. But as important this fact might be, it is supposable that living isolated from others, or, on the contrary, being completely dependent on them, wouldn’t probably make us happy, neither. Hence, we asked also as how relevant participants perceived other facets of life being aged. We classified the different aspects to three categories: (1) life autonomy (LA; e.g., to fend for oneself), (2) social life (SL; e.g., having persistent social network), and (3) healthcare (H; e.g., monitoring of relevant vital parameters). A multivariate analysis of variance with the variables age and gender revealed no effect of different age groups (F(6,230) = 1.1, n.s.), but there was a significant influence of gender on the three categories regarding quality of life (F(3,114) = 4, p = 0.009). As it is visualized in Figure 2, women rated aspects of autonomy (e.g., having secure income/savings) with a mean value of 16.6 (SD=2.1; max. = 18), social contacts (M=21.5, SD=2.1; max. = 24) and caring about own health (M=10.2, SD=1.9; max. = 12) as significantly more important at the older age as the men (M_LA=15.7, SD_LA=2.1; M_SL=20.3, SD_SL=2.4; M_H=9.4, SD_H=2).

The interaction between age and gender missed statistical significance (F(6,230) = 0.9, n.s.).

**Perceived Misgivings at Older Age**

Similar designed as the life quality aspects, were items about misgivings regarding older age. Ten items were clustered to three categories: (1) dependence of others (e.g., becoming burden for other people), (2) social loneliness (e.g., being social isolated), and (3) health issues (e.g., decrease of cognitive and physical skills). A multivariate analysis of variance showed no (interacting) effects of age and gender. There was solely a tendency in the mean values (T = -1.8, p < 0.1) discovered in the group of older participants between females (M=9.7, SD=3.3) and males (M=11.4, SD=2.5).

Figure 2. Effect of gender on aspects of life quality at old age (N=122)
regarding misgivings of social loneliness (max. = 18) showing that the men are slightly more afraid to stay alone at older age.

Apart from that, the average values in the particular categories of perceived misgivings in the elderly were only moderate pronounced: firstly, the respondents were not very afraid of later dependency of others, reaching M=12.1 (SD=3.1) out of 18 possible points, secondly, regarding social loneliness the whole sample averaged M=10.8 (SD=3.5) out of maximum 18 points, and thirdly, the misgivings as to the own health were in all participants at the average lower as expected (M=16.3, SD=4.3; max. = 24), too.

Active and Passive Attitude Towards Ageing

Additionally, it was surveyed, which conception of ageing in terms of active and passive coping with daily routine duties is present. With the concept of active ageing we mean an age-adapted spirited activeness, which comprehends activities in different areas of life, e.g., fitness and healthy nutrition for a better health, (grand-)child care, being up to date regarding technology developments, being useful to the society where lived, etc. A passive attitude towards ageing, in contrast, is rather the concept of remaining inactive, which can be characterized by a lack of initiative, feelings of powerlessness and vulnerability, age-related depression, being socially isolated, and the absence of performance-ambition, etc.

An analysis of variance showed no effects of age and gender for the active attitude towards ageing. Assessing mean values differences with a T-Test it was found by trend (T=1.8, p<0.1), that in the group of respondents aged between 55 and 80 years females reached higher average values in active attitude (M=49.9, SD=6.1; max. = 60) than males (M=46.5, SD=5.4). Thus, older aged women marginally more then men in this age group believe that it is worth it to manage their social and private life in an active way also in older age.

In contrast, ANOVA with the variables age and gender for the passive attitude towards ageing revealed an effect of age (F(2,116)=6, p=0.003) but not differences in the both sexes were found in this regard. Here, the mean value in the young participants group was M=16.5 (SD=3.9), in the middle-aged group an average of M=16.7 (SD=4.5) was assessed, and people in the older group scored at an average M=19.7 (SD=4.5) out of 36 possible points (the higher the score, the higher is passive attitude; Figure 3). Interestingly, the impact of age becomes weaker (F(2,113)=3.9, p=0.024) when the covariate education (F(2,113)=6.8, p=0.010) is included in the analysis revealing in the groups of middle-aged (r=-.37, p<0.05) and older respondents (r=-.39, p<0.05) the passive attitude while ageing increases with minor education. Apparently, the level of education determinates the negative attitude towards ageing even stronger than the age itself.

Summing up the section of ageing concepts, we can say that it is unanimously agreed in all age and in both gender groups of the respondents to the fact, that it is very important to live in the own four walls at older age. However, elderly women take aspects of life autonomy, social
contacts and the own healthcare more seriously than men. The misgivings at the older age were less pronounced than expected and the different groups did not differ significantly in their scores. In respect to the active and passive attitude towards ageing it was revealed that the negative attitude increases, the older the age of respondents is, however, the age differences in this regard become more indistinct the higher participants’ level of education.

At this point we can therefore partially confirm the hypothesis (H1) that individual factors meaningfully influence respondents’ different aspects of ageing concepts. To what extent will be focused later on in the result section (see: relationships between usage of medical technology and ageing concepts).

**Users’ Technical Learning History**

As known from prior research (e.g., Arning & Ziefle, 2008; Wilkowska & Ziefle, 2009b) users’ experience with proliferated technical devices and the degree, to which a person believes in own ability to handle them, influence the acceptability and usage of innovative technologies. In this section we assess how different technology generations and gender impact these factors, whose interplay forms the technical learning history of every user.

**Technical Experience**

In the first place, it is noteworthy to define the mentioned technical experience. In the present study the variable technical experience was composed as a sum of two components with respect to popular technical devices (e.g., personal computer, mobile phone, digital camera): the frequency of usage, and the subjective perceived level of difficulty in terms of usability while handling them.

An one-way ANOVA showed significant effects of age (F(2,108) = 27.8, p ≤ 0.001) and gender (F(1,108) = 12.5, p ≤ 0.001) on technical experience. The mean value differences in the three age groups were substantial: the highest technical experience showed young participants (M=43.9, SD=7.9), which were followed by the middle-aged respondents with the mean of M=39.2 (SD=11.3). The average value of technology users aged between 55 and 80 years was with M=26.8 (SD=14.2) out of a maximum of 60 points the lowest in the sample. The arithmetic mean differences are unambiguous (Figure 4, left), but when looking at the standard deviations it becomes clear that the interacting with technology and the using frequency differ all the more with increasing age. This result suggests that the younger the persons are, the more consistently is their usage of common technical devices. It does not implicitly mean, that (some) older people are not equally technical experienced, but it lets simply realize, that in the older generation the gap between the technical ‘experts’ and ‘laymen’ is much bigger than in the younger one.

As mentioned above, also a meaningful gender-specific difference was found regarding technical experience: male respondents reached a mean value of M=39.9 (SD=12) points and female participants scored an average of M=33.7 (SD=13.9) points. Thus, according to the reported data men are more technical experienced than women (Figure 4, on the right), though no interacting effect of age and gender was observed (F(2,108)=1.8, n.s.).

**Subjective Technical Confidence**

Beside technical experience, the own confidence with handling technical devices is regarded as an important part of user’s technical learning history. In the present study both variables are positively correlated (r=0.5, p≤0.001) and implicate that persons with higher technical self-confidence are also more technical experienced.

In an analysis of variance we assessed the influence of age and gender on subjective technical confidence (STC) and found statistically meaningful effects of both variables. The impact of age (F(2,115)=14.6, p≤0.001) presented in Figure 5 left showed that – similar to the dispersion of
Figure 4. Effects of age (left) and gender (right) on technical experience (N=122)

Figure 5. Effect of age (left) and gender (right) on Subjective Technical Confidence (N=122)

technical experience in the sample – the youngest respondents possess the highest technical self-confidence (M=76.3, SD=14.3), the middle-aged persons follow with mean of M=70 (SD=15.7) points, and the senior group estimates its self-
confidence with technical devices at an average of $M=60.6$ (SD=12.5) out of 100 possible points.

In addition, the gender effect ($F(1,115)=19.4$, $p\leq0.001$) shows that male participants ($M=74.1$, SD=13.9) more than females ($M=63.6$, SD=15.6) believe in their own ability to manage well technical devices (see Figure 5 right).

The interaction of age and gender in respect to subjective technical confidence missed statistical relevance ($F(2,115)=1.6$, n.s.).

Motives to Use Information and Communication Technologies

Finally, in order to complete the overall impression about the technical learning history in the explored sample we assessed respondents’ motivation and barriers to use ICT, respectively. For this purpose participants valuated pro- (e.g., a high fascination by technology) and contra-arguments (e.g., suspiciousness of technology).

Highly significant effects of age ($F(4,232)=5.7$; $p\leq0.001$) and gender ($F(2,115)=11.2$; $p\leq0.001$) were found. No interacting effect was present. This finding reveals that men show distinctly more positive and less negative biases towards information and communication technologies in comparison to women (independently from age). Also, the positive attitude towards technology is higher – and contrariwise the negative attitude is lower – the younger the respondents are, and in opposition to that, the scores in using-motives decrease and those of using-barriers increase the older the participants are. The allocation of the data can be taken from Figure 6.

Summing up, the section regarding technical learning history revealed firstly, that there are meaningful differences between male and female technology users. Males show generally more technical experience and – probably because of that – higher self-confidence with common technical devices; in comparison to women men are also characterized as more positive towards information and communication technology (usage).

Secondly, the observed age effects let assert that technical experience and self-confidence in technical context decrease with increasing age. Similar structured are the motives pro and contra usage of this kind of technology: the younger was the age of respondents, the more interest, fascination, joy and understanding towards technology was reported (positive motivation), and, in contrast, the negative biased statements – such as averseness towards and suspiciousness of technology – found all the more affirmation the higher aged were the respondents. Thus, the presented findings confirm the assumption (H2), that individual factors affect users’ technical learning history as well as their motives to use common ICT-devices.
Medical Technology and User Diversity

Will the same pattern be found for the medical technology (MT)? In order to explore how the opinions regarding medical assistance in different technology generations and in both gender-groups are, we collected in another part of the questionnaire data about the general attitude towards MT, (anticipatory) willingness to use MT, as well as pro- and contra-arguments for MT-usage.

General Attitude and (Anticipatory) Willingness to Use Medical Technology

First of all we enquired respondents’ general and unbiased attitude towards well-known medical devices, such as blood pressure meter, insulin pump, artificial pacemaker, etc. For this purpose participants had to estimate their degree of approval or rejection on a 5-point Likert-scale. Thereby, the higher the reached score was, the more positive was the attitude.

With the next step we intended to provoke a compelling situation: in order to avoid that (healthy) participants of our survey feel unconcerned by questions regarding usage of medical devices we instructed them to imagine to suffer from chronic illness (e.g., coronary heart disease) before answering of the subsequent questions. In this way we achieved anticipatory willingness to use MT in a situation of urgent needs.

In a multivariate analysis of variance a significant effect of age ($F(4,210)=3.9$, $p=0.004$) and an interacting effect of age and gender ($F(4,210)=2.6$, $p=0.040$) were revealed for both variables, when the moderating variable financial status ($F(2,104)=2.4$, $p=0.1$) was added as covariate into the analysis. According to this, the positive general attitude to use medical devices in the groups of youngest ($r=.34$, $p<0.05$) and oldest participants ($r=.31$, $p<0.05$) was connected to a higher income level. The mean values in the particular age groups are presented in Table 4 for both, the general attitude towards and the willingness to use medical devices.

It is a highly interesting finding, which makes possible to observe how powerful the gravity of a situation is. As can be seen the opinions change when people feel concerned by an illness. Regarding the general attitude towards medical technology the group of youngest respondents reached the highest score, while middle-aged participants scored at the lowest. In contrast, in case of illness the means are invert, so that the middle-aged respondents are most willing to use medical technology. The group of oldest participants in the sample showed a moderate attitude towards medical technology and – around others – the lowest willingness to use medical devices.

Though, the resulted scores in both considered variables were relatively high pronounced, which makes evident that there was a positive general attitude towards, and relatively high willingness to use medical technology.

![Table 4. Mean values (and SD) for the attitude towards and willingness to use Medical Technology in the three age groups](chart.png)
Additional, the main effect of gender as a factor missed the statistical significance, but there was a significant interaction effect of age and gender. As presented in Figure 7, especially middle-aged males differ comparing their general attitude (mean falls significantly even behind the score of older respondents!) and their willingness to use medical technology in case of illness, which exceeds by far the values of both younger and older aged males. In contrast, the differences in females are not that manifest: they showed positive general attitude towards medical technology, and also, relatively high willingness to use those devices while sickness.

**Motives to Use Medical Technology**

In analogy to ICT, participants’ pro- and contra-motives for using medical technology were surveyed in the study. Regarding the positive motives there is no age effect present, showing that they not vary across technology generations (means range at about 20 out of 25 points). However, a marginal gender effect was detected (F(1,116)=3.2, p<0.1) revealing women (M=21, SD=2.9) to be slightly more positive motivated to use medical technology in comparison to the male respondents (M=19.8, SD=3.5).

When focusing on the arguments against the usage of medical assistance (Figure 8), a significant effect of age was present (F(2,116)=3.3; p<0.05). Gender effects, in contrast, could not be revealed. The age effect becomes even more evident when co-variable ‘financial status’ (F(1,105)=8.7, p<0.01) is added into the ANOVA, showing that especially in the oldest age group the disapproval of medical technology usage increases, the weaker the financial circumstances are (r=−.46, p<0.01). Though, the mean values for contra-arguments of medical technology usage lie between 11 and 13 points (maximum 25) showing that those reported arguments against medical devices are at an average much lower pronounced than the motivation to use them.

Summarizing, two findings are especially noteworthy in context of medical technology usage. First is that the respondents generally show positive attitude towards medical technology and they are willing to use it – especially in case of (chronic) illness. Thus overall, there is more positive than reluctant response to medical tech-

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**Figure 7. Interacting effect of age x gender on attitude towards (left) and willingness to use medical technology (right)**
User Diversity as a Challenge for the Integration of Medical Technology

Figure 8. Effect of age on contra-arguments for usage of medical technology (N=122)

Technology. Second is that the oldest participants (the early technical generation) reveal to be most critical and negative towards the usage of medical technology. This result seems somewhat ironic, as mainly in this generation the necessity to use medical technology is, or it will soon be – according to the incidence of chronic illnesses increase with aging –, most probable.

The findings confirm our hypothesis (H4): users’ individual characteristics like age, gender and financial situation influence considerably the general attitude towards and willingness to use medical technology, and they determine user’s motives and barriers to use it.

Assessment Criteria for Medical and ICT Devices

As this attitude survey focuses on innovative medical systems in home environments, it is also interesting to find out – independent from the attitude towards the particular technologies – (1) as how relevant (future) users assess different criteria in this regard, (2) if there are differences within user groups (age, gender), and (3) if the opinions vary in dependence of the technology character (medical in comparison to information and communication technology). For this reason, data regarding aspects of device-functionality, -security and -appearance were collected. The specified criteria (e.g., technical reliability, strict access control, attractive design) had to be assessed on a 6-point Likert-scale (degree of relevance, from 1=’not relevant at all’ to 6=’very relevant’).

In our analysis the value of 3.5 separates relevant from non-relevant criteria.

Figure 9 illustrates mean values of several criteria comparing medical and ICT-technologies for the whole sample. Multiple findings become obvious viewing the graphic. As the three most important criteria for the users of medical technology and ICT emerge the technical reliability, high usability and the newest technical standard of devices. Thereby, the first – reaching almost the maximum value of the scale – and the second one are comparably pronounced in degree of relevance, and they are comparable valued in both technologies, while the latter differ considerable showing that newest technical standard is much more important to the users in medical than in ICT context. Similar pattern is to observe in case of seal of quality, which is significantly more important (T=3.8, p≤0.001) for the medical device. In contrast, criteria like low price, access control and as most notably attractive design seem to be more relevant for ICT devices, which does not surprise considering a different point of view: it might be perceived as personal trinket or a kind of embellishment. Those criteria play for users of medical devices a much less important role; for those people expect rather an unfailing functionality (even for a higher price) than good looks.

Moreover, it is interesting that almost all of the criteria exceed the value of 3.5, which is yet assumed as a lowest value for perceived relevancy. Only the criterion inconspicuousness reaches exact this value for medical technology showing that people do not really care, if others see it or
User Diversity as a Challenge for the Integration of Medical Technology

As it was already shown in the earlier analyses, user diversity represents a big challenge for integration of medical assistance. Thus, also at this point, it is worthwhile to zoom in and analyze the assessment data more detailed in order to explore how different technical generations assess those criteria and if there is also gender diversity in this regard.

Assessing the criteria for medical technologies, the analysis of mean values (Table 5) reveals significant differences within the age groups in reference to: approved manufacturer’s label ($F(2,119)=4, p<0.05$), inconspicuousness ($F(2,119)=5, p<0.01$) and attractive design ($F(2,119)=3.4, p<0.05$). The insignificant differences in as the most relevant assessed criteria make evident that independently from age users agree upon the importance of technical reliability, high usability and newest standard – to call only the highest rated criteria – of medical assistance devices. Moreover, the youngest technical generation pays more attention to well-established labels and design of the device compared to older generations, though, young people do not want it to be noticeable for others. However, with increasing age we observe an ebbing of relevance for those criteria. Now, solely well-known labels play yet a role for medical devices reaching the average value of 3.5.

In contrast, the age differences regarding criteria for ICT devices are more distinct. Indeed, the highest assessed criteria are still the same as for medical technology but there is significant diversity in the three technical generations. High usability for instance ($F(2,115)=3.9, p<0.05$) become more important with increasing age, and also seal of quality ($F(2,115)=3.4, p<0.05$) and low price ($F(2,115)=3, p≤0.05$) let observe similar pattern. Other characteristics varying meaning-
ful within the age groups are the newest technical standard ($F(2,115)=6.2, p<0.01$), approved label ($F(2,115)=4.3, p<0.05$), as well as attractive design ($F(2,115)=6.5, p<0.05$). The latter two characteristics named are especially important for the youngest respondents’ group.

Moreover, user diversity analyses with regard to perceived relevancy of different criteria in medical and ICT context were carried out also for both sexes. Table 6 merges criteria’s mean values for men and women for both technologies.

Regarding medical devices, there are only two of the given criteria, which differ significantly in females and males. According to this, females attach more importance to low price ($F(1,120)=6.1, p<0.05$) and attractive design ($F(1,120)=4.1, p<0.05$) of a medical device, whereby the latter achieves not even the boundary value of relevance, i.e. the design is not fundamental for buying or using it. The highest rated criteria, in contrast, do not significantly vary gender-related, which shows that men’s and women’s opinions mostly match about the relevance of similar criteria for medical technology.

Seen from the perspective of IC-technology assessment for the given criteria results exactly the other way round, i.e. the biggest gender-related differences are related to the as relatively important

Table 5. Mean values of assessment criteria for MT (left) and ICT (right) in three age groups

<table>
<thead>
<tr>
<th></th>
<th>Medical technology devices</th>
<th>ICT devices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20-35 years</td>
<td>36-54 years</td>
</tr>
<tr>
<td>tech. reliability</td>
<td>6</td>
<td>5.8</td>
</tr>
<tr>
<td>easy handling/high usability</td>
<td>5.2</td>
<td>5.4</td>
</tr>
<tr>
<td>newest techn. standard</td>
<td>5.4</td>
<td>5</td>
</tr>
<tr>
<td>seal of quality</td>
<td>4.5</td>
<td>4.3</td>
</tr>
<tr>
<td>low price</td>
<td>3.8</td>
<td>4.1</td>
</tr>
<tr>
<td>access control</td>
<td>4.2</td>
<td>4.1</td>
</tr>
<tr>
<td>Approved label</td>
<td>4.3</td>
<td>3.5</td>
</tr>
<tr>
<td>inconspicuousness</td>
<td>4.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Attractive design</td>
<td>3.3</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Table 6. Mean values of assessment criteria for MT (left) and ICT (right) in gender groups

<table>
<thead>
<tr>
<th></th>
<th>Medical technology devices</th>
<th>ICT devices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>females</td>
<td>males</td>
</tr>
<tr>
<td>tech. reliability</td>
<td>5.9</td>
<td>5.9</td>
</tr>
<tr>
<td>easy handling/high usability</td>
<td>5.4</td>
<td>5.3</td>
</tr>
<tr>
<td>newest technical standard</td>
<td>5.2</td>
<td>5.1</td>
</tr>
<tr>
<td>seal of quality</td>
<td>4.7</td>
<td>4.3</td>
</tr>
<tr>
<td>low price</td>
<td>4.3</td>
<td>3.7</td>
</tr>
<tr>
<td>access control</td>
<td>4.2</td>
<td>3.9</td>
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<tr>
<td>Approved label</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td>inconspicuousness</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Attractive design</td>
<td>3.2</td>
<td>2.6</td>
</tr>
</tbody>
</table>
estimated criteria like high usability \( (F(1,116)=5.5, p<0.05) \), seal of quality \( (F(1,116)=7.3, p<0.01) \), and low price \( (F(1,116)=8.7, p<0.01) \). Thereby, females ascribe more importance to these criteria, which implies that they make higher demands on ICT devices in comparison to males.

Concluding, as could be shown by means of assessment criteria, technology usage and acceptance – whether medical or ICT – are subjects to the rules of user diversity. Thereby, information and communication technologies are liable to much more age and gender differences in comparison to medical technology. Regarding medical technology users do not differ in dependence of age or gender in their opinions about the relevance of criteria like technical reliability, high usability and newest technical standard, which represent the most important characteristics of the devices. The differences in this context are only that the youngest generation pays more attention to approved labels and design attractiveness, and females demand greater deal of the price in comparison to the males. Thus, the integration of medical assistance devices could be easier as expected as long as there are mature solutions for the requested criteria.

Interplay of Research Factors

Closing the result section we want to examine the proposed research model and verify how the research variables are connected in order to find the best predictors for a successful integration of medical assistance in home environments. For this purpose we at first inspect the correlative relationships of the main factors in this study (see Table 7), then we analyze the interrelations of ageing concepts and usage of medical technology (see Table 8) and we examine the connection of pro- and contra-arguments regarding different technologies (medical and IC-technology) at last. We used bivariate correlations: for interval-scaled data the results were taken from Pearson’s product-moment coefficient, for ordinal-scaled data we used Spearman’s rho correlations, and for the dichotomous variable – gender – point-biserial correlation coefficients were taken.

User Diversity and Research Variables

As the factors age and gender acted as the main indicators for user diversity we correlated these with variables used in the present survey. Additionally, the relations of educational level as well as financial status – which served as moderating variables – were tested, although, through this moderating character it was not intended to verify the influence of these variables, but only to emphasize the diversity of respondents participating.

Inspecting Table 7 it is noticeable that the variable age is mostly related to variables of user’s technical learning history: with increasing age technical experience and subjective technical confidence fall remarkable off, while motives pro ICT usage diminish and motives contra ICT rise. Higher age is also moderately associated with rather passive attitude towards ageing and there is a marginal connection to the motives against using medical technology, which have been all the more acknowledged the older our respondents were.

Also gender is most frequently related to the technical history: females in comparison to males are endued with less technical experience and a lower technical self-confidence, as well as they oftentimes object to pro-arguments of ICT usage. The positive coefficient with perceived aspects of life-quality means in this case that the women more than the men attach importance to autonomy, social contacts and healthcare being aged.

The level of education moderates several of the research variables. According to the results in Table 7, participants with higher educational level are less worried about dependency of others, social loneliness and health issues, and show lower passive attitude being advanced in years. Higher education is also positively connected with technical experience, higher technical self-confidence, and less agreement to arguments against using medical and ICT devices.
User Diversity as a Challenge for the Integration of Medical Technology

At least, financial status is positively associated with motives pro ICT usage and negatively related to arguments contra medical technology usage, which suggests that the better respondents are well off, the more they turn towards technologies usage.

Relationships between Usage of Medical Technology and Ageing Concepts
In our explorative work it is also of interest, to which extent usage of medical technology is related to the aspects of ageing. Besides the influence of user diversity on those (H1), which was presented earlier in this section (see analysis of ageing concepts and users diversity) we assumed in the second part of the hypothesis that different concepts of ageing are also connected to the usage of medical assistance. Analyzing the correlative relationships (Table 8) we can now specify these relations. The general attitude towards medical technology is positively associated especially with high quality of life (autonomy, social network, health-control) and with active attitude towards ageing. There is also a weak relation to the estimated misgivings suggesting that worries about dependency, social isolation and health issues in older age are linked to positive thinking about the medical assistance. The (anticipatory) willingness to use medical devices is also positively connected to the active attitude and negatively to the passive attitude when aged. Thus, those, who are disposed to actively organize their everyday life being aged, tend to use medical technology in opposite to those with rather passive attitude.

Looking on the motives pro using medical devices, interesting findings appear: firstly, the idea of high life quality is linked to rather lower motivation of medical technology usage. In fact,
one could expect the opposite, that a proper healthcare – as an aspect of a good life quality – is rather positively connected to usage of medical assistance. Secondly, greater worries about some aspects of ageing are accompanied by higher agreement to pro-arguments for the usage. This is not surprising, when assumed that the more supposed issues are pronounced, the probably higher is the motivation to use medical assistance. Thirdly, the conception of active daily routine arrangement in the higher age correlates significantly with the motivation to use medical technology. In contrast, passive attitude is not related to that.

Finally, the analysis reveals a negative interrelation between active attitude, and also, a positive interrelation between passive attitude and arguments against using medical assistance. Thus, active persons rather disagree to the contra-arguments and people with higher passive attitude affirm them all the more.

Summing up, we can now fully approve the formulated hypothesis H5: users’ diversity impacts respondents’ referred ageing concepts, and those are meaningful associated with aspects regarding usage of medical technology in their home environments.

### Relationships between Pro- and Contra-Arguments for Using Medical and IC-Technologies

Additionally, we examined if and how strong pro- and contra-arguments for using medical and ICT devices are interrelated. According to our assumption in H3, persons with a positive attitude towards information and communication technologies show also a positive attitude towards usage of medical technology. Referring to the correlations in Table 9, peoples’ pro-motives for using those technologies are not significantly connected. This result allows the conclusion, that the motivation to use common ICT devices does not automatically assure an agreement to the arguments pro using medical assistance. Confronted to that we must refuse the first part of the hypothesis. However, we assumed further that – analogue – people with negative ICT-attitude show correspondent more approval to the arguments against usage of medical assistance. Therefore, the findings let confirm the second part of our hypothesis, showing that respondents with high agreement to arguments contra using common ICT devices also rather refuse using medical technology assistance. However, it is astonishing, that there is more general consensus to the results for usage-negation of both technologies than for usage-endorsement.

Moreover, it is not surprising that pro- and contra-arguments within particular technologies (ICT: r=−.34; MT: r=−.25) are significantly negative correlated, which actually enforces the impression about respondents’ opinions in the one or another context.

Summarizing, the results of correlative analyses reveal that users considerably differ in their attitudes towards technology usage, and that this diversity is present in different factors influencing it. Regarding the general opinions about medical technology a basically favourable trend becomes noticeable, but the usage motives in terms of pro-arguments are not primarily influenced by user characteristics. On the contrary, reported

### Table 9. Relation between pros and cons for using ICT and MT (N =122; ** p≤0.01)

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Contra-arguments are significantly impacted by age and meet all the more approval the older the users are. Moreover, referred ageing concepts are exceedingly related to the usage of medical technology. Thereby, especially higher perceived life quality and the active attitude in older age are strongly connected to a positively general attitude and more agreement to the motives pro medical technology. In addition, it could be shown, that negative attitude towards popular ICT devices comes along with refusal of medical technology usage. Thus, it is noteworthy, that those usage barriers were identified to be more decisive and more essential to predict the general acceptability of medical technology in contrast to the positive expectations connected to the usage of medical technology.

CONCLUSION

Overall, this exploratory study revealed that user diversity is in fact a prominent factor that modulates the acceptance of medical technology. We considered several user factors in this study (even though this selection is of course incomplete): the general technical experience, educational and economic factors, impact of individual ageing concepts, and also the self-confidence when using technical devices. In combination with age and gender we analyzed their influence on acceptance of medical technologies. Concluding, on the one hand the key factors revealed in this study are concisely compiled. On the other hand, a final remark is directed to the impact of user-centred designs.

Key Outcomes

First of all, there is “good news”: respondents generally showed a positive attitude towards medical technology in general and they indicate to be willing to use it – especially in case of (chronic) illness. Thus overall we could draw from the findings that there is more positive than reluctant response to medical technology. Second, is – representing the “not-so-good news” – that the group of oldest participants (the early technical generation) reveals to be most critical and reluctant towards the usage of medical technology, what is noteworthy, when considering that the use of medical technology is most probable in this generation.

When focusing on the technical experience and the reported technical self-confidence, we see the typical age and gender bias. With increasing age technical experience and subjective technical confidence decrease. Older adults tend to accept a rather passive attitude towards ageing. Also gender is most frequently related to the technical history: females show lower competence levels and have lower self-confidence when using technology. Though, women attach higher importance to autonomy, social contacts and healthcare being aged in comparison to men.

Individual ageing concepts are related to the usage of medical technology in a very prominent manner. The higher the perceived life quality and the more pronounced the active attitudes in older age the more are medical technologies accepted. Persons, which have a negative opinion about technology in general, also show higher refusal of medical technology. Thus, it is noteworthy, that the expected usage barriers are forming the overall attitude towards (medical) technology, rather than the expected gains.

The level of education is also an important factor for aging concepts. People with higher educational level are less worried about dependency of others, social loneliness and health issues, and they show lower passive attitude at older age. Higher education is also positively connected with technical experience, higher technical self-confidence. At last, financial status is positively associated with the positive attitude towards ICT and the less negative attitude towards medical technology usage.
Importance of User-Centred Designs

One could critically argue that any exploring of such complex systems like the acceptance of medical technology is “useless”, relying on the assumption that older users will automatically and easily accept medical technology. According to this perspective, older and frail users must want to use medical devices in order to keep independency and mobility, and will use medical technology – if necessary – as they simply do not have any alternatives. Though, considering that “aging” is not a unique phenomenon, but entails different developmental processes, attitudes, and biographical influences, this assumption seems rather naïve. Also, it neglects that it is not only the patient itself, who should be considered when asking for acceptance patterns, in this context many more groups or stakeholders (e.g., nurses, doctors, family members and physicians) need to be included in acceptance studies. Only by truly human-centred designs, which respect user diversity and living contexts, a situation can be created, in which all persons involved are considered adequately. On this base, appropriate communication and information concepts towards usage and importance of medical technologies in home environments can be developed, which are completely missing yet.

FUTURE TRENDS

Future studies will have to consider the specificity of the outcomes reported here and compare them to attitudes and utilization motives in other medical technology contexts. This is of specific importance given the fact, that the very same arguments for or against a specific medical technology change their relevance or even their weight when the using context changes.

Current approaches of technology acceptance describe a static perspective of acceptance, whereas the acceptance of medical applications might have many dynamic components, which are influenced not alone by disease-related changes in health state, but also by different coping strategies and compliance behavior. Therefore, future approaches should aim at the integration of health-related constructs – such as compliance behaviors and coping-styles – and dynamic components of acceptance patterns in the theoretical explanation as well as in the modeling of acceptance and utilization behavior with respect to medical technology.

A cross-cultural comparison of different societal aging concepts and their relation to acceptance of medical technology could also represent a valuable research topic. Also, it will have to be found out, if the caveats reported by respondents vanish, when people become familiar with these technologies.

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**ADDITIONAL READING**


**KEY TERMS AND DEFINITIONS**

**Aging Concept:** Aging concept described here refers to the comprehensive view of aging process and its consequences to the person concerned. It includes (1) the perceived quality of life regarding autonomy, social life and healthcare, (2) misgivings while aging concerning dependency of others, social loneliness and health issues, as well as (3) the active vs. passive attitude towards aging itself.

**Contra Arguments against using Medical Technology (Cons):** Refer to perceived drawbacks and disadvantages i.e. from medical technology usage resulting barriers, which lead to reluctance or hamper the acceptance and willingness to use it; for example the feeling of dependency, lacking trust of device’s reliability, belief of insufficient data protection, etc.

**Medical Technology (MT):** It relates to innovative assistive technologies with regard to person’s health encompassing a wide range of health care products or devices, which can monitor different vital bodily parameters (e.g., blood pressure, blood coagulation) or treat diseases that affect humans (e.g., insulin pump in the treatment of diabetes mellitus). Its tasks are to support and facilitate patients’ health care and to improve their life quality.

**Pro Arguments for using Medical Technology (Pros):** Reflect perceived advantages and benefits i.e. positive motives, which induce people to use medical assistive technology in their home environment. This can be for instance the perception of an improved control of the own health, impression of better chance to react in case of alarming health parameter values, belief of disease prevention, etc.

**Smart Home:** The term refers to intelligent technical solutions implemented in the private home environment depending on and adjusted to the particular needs and requirements of the resident(s). In the context of the present study it is meant with regard to the usage of medical technologies.
Technical Learning History: The term comprises user's technical experience (consisting of the usage frequency and the perceived usability of popular technical devices like for instance personal computer, mobile phone) and subjective technical confidence (i.e. the degree to which a person believes in the own ability to solve a technical problem) in the interaction with technical devices. It is assumed that people with higher technical experience exhibit higher self-confidence in technical matters.

User Diversity: The term user diversity describes in this context users' characteristics like age, gender as well as the moderating influence of users' level of education and financial status.