

Accounting for User Diversity in the Acceptance of Medical Assistive Technologies

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Abstract. This paper describes two studies focusing on acceptance of medical technologies from different points of view – in general and in particular. Acceptance of medical assistive technologies was analyzed considering influences of user diversity factors. The first study explored how people perceive the aging process itself and showed how this perception is associated with general aspects of acceptance of medical technology in terms of usability. The second study was conducted to analyze acceptance of a specific technology – a smart robot – revealing that the acceptance of a concrete medical device is more specific and that especially age and gender form its underlying structures.

Keywords: aging concepts, user diversity, usefulness, medical technology.

1 Introduction

Being old and frail but still the wish to live independently from nursing homes – a situation that will be relevant to almost everyone at some time in life. Due to demographic changes and decreasing supply shortfalls of societal health insurance funds, people need alternatives for satisfying this desire [1]. Medical assistive technologies (smart health, ambient assisted living (AAL), personal health care systems) offer possible solutions [2]. Recent studies show that technology acceptance cannot be taken for granted and that it is a crucial factor for a successful rollout [3]. Two empirical studies are reported that examine the role of user diversity that might influence users' willingness to use medical assistive technologies.

1.1 Acceptance of Medical Assistive Technologies

The theoretical framework is based on the technology acceptance model (TAM) [4] and its refinement UTAUT [5]. TAM states the perceived ease of using a system and the perceived usefulness as key components of technology acceptance. However, with the increasing diversity of users as well as the diversity of technical systems (visible vs. invisible, local vs. distributed) and using contexts (fun and entertainment, medical, office) the end-users are confronted with, more aspects could be relevant for understanding acceptance – beyond the ease of using a system and the perceived usefulness [6]. Studies

dealing with the acceptance of medical technologies show that it is questionable assume that acceptance for medical technologies can be fully understood on the base of prevailing knowledge of technology acceptance drivers so far [7]. Two major arguments are in favor of taking a more differentiated view when analyzing acceptance of medical technologies: First, e-Health technologies are predominately addressing the seniors, which represent a highly heterogeneous user group (differing e.g. in (technical) experience, abilities, values, economic and health status). Second, many technologies in the medical context do overstep personal intimacy limits, and therefore could be bothered by justifiable concerns about privacy, intimacy and loss of control.

1.2 The Impact of User Diversity

In the context of acceptance of medical assistive devices, users' diversity is an indispensable factor. A number of user factors have been already considered in previous studies on technology acceptance, although some factors did not receive attention, especially in this sensitive context, yet. A few studies focussed on gender differences in attitudes towards aging concepts and related medical care respectively life-prolonging technologies. Women in general were less likely to want treatments to prolong life [8]. Further, women voiced "other oriented" reasons for their opposition, particularly not wanting to be a burden for others [9]. Another gender difference regards the expertise concerning the use of information technologies: throughout, men were found to have a greater interest in and a more positive attitude regarding technology usage, due to a higher self-esteem and familiarity with information technologies [10].

When considering age in combination with gender, another aspect concerning the use of medical technology emerges: gender differences in the (social) aging process. Men have more problems organizing their daily life when living alone in older age, due to traditional role allocation and the fact that most of the house activities were the wife's part. This is also the reason, why women in older age have fewer problems to maintain contacts although they are living alone [11]. In view of technology acceptance research within the medical context it seems to be necessary to not just notify whether gender or age differences exist in respect to the willingness to adopt these technologies, but to get a deeper understanding of the underlying reasons why they exist.

2 Study 1

2.1 Method

Quantitative Data Collection. On the basis of insights gathered in focus groups, a questionnaire was developed. Apart from demographical data, three units of questions with respect to aging had to be answered on a 6-point Likert scale. The first set of questions in this regard inquired, how important participants rate different aspects of life in old age: self-reliance (e.g., "not to be a burden to anyone"), social integration (e.g., "to have a persistent social network"), and own healthcare (e.g., "monitoring of relevant bodily functions"). The second and third question sets dealt with positively and negatively connoted aging images (e.g. positive: "I believe that it is throughout possible to achieve a great deal at old age", e.g. negative: "Being older aged means to me being weaker and frailer, and I don't believe that I can do anything against it").

Reliability of items was checked by item analysis (Cronbach's $\alpha=.70$). In addition, acceptance in terms of usefulness of medical assistance in home environments was collected (e.g., "Medical assistance devices at home are useful, because they enable older/chronically ill people to live a dignified and independent life"). The fill in took about 20-30 minutes.

Research Variables. As *independent variables* age and gender were considered in all statistical analyses. As acquisition and usage of medical assistive devices is connected with more or less high costs, respondents' economic status (annual earnings) was also taken into consideration in some analyses. As *dependent variables*, firstly concepts regarding high quality of life at old age were examined (self-reliance, social integration, health monitoring). Second, positive connoted images of aging (a sum of items with respect to defined goals, ability to solve problems, contacts with family and friends, seeking for more knowledge, etc.) and negative connoted images of aging (a sum of items with respect to social isolation, weakening cognitive performance, lacking motivation, loss of autonomy and self-confidence, etc.) were analyzed. Third, besides aging concepts the impact of independent variables on acceptance of medical technology (e.g., blood pressure meter) in terms of its perceived usefulness was assessed.

Sample Description. Respecting the recruitment of participants, younger adults were mostly university students of various academic fields and persons being in vocational training. Middle-aged and older participants were reached partially through the social network of the authors, partially by advertisements in local newspapers and covered a broad range of professions. In the study 1 a total of 124 respondents, aged between 20-80 years (47% female) participated. The reason for the broad range of participants was to identify aging concepts at different stages of life and to compare the results in both gender groups. For statistical purposes, three age groups were formed: The youngest group consisted of 42 adults (20-35 years of age; $M=29$, $SD=4$; 57% males), the middle-aged group of 41 persons (36-54 years of age; $M=45$, $SD=5.3$; 56% women) and the oldest group had 41 participants (55-80 years of age; $M=64.3$, $SD=6.9$; 42% female). According to their economic status we divided participants into three groups: annual earnings $<20.000\text{€}$ / year (1=low), $<40.000\text{€}$ / year (2 = middle), and $>40.000\text{€}$ / year (3=high). As not all respondents stated their earnings, we gathered data from 115 respondents in this respect. The annual income differed between age groups ($F(2,109)=9.7$, $p<0.01$) revealing that the youngest participants' salary is, on average, the lowest, followed by middle-aged and then by the oldest respondents. Also, gender effects were found ($F(1,109)=15.4$, $p<0.01$): while females reported annual incomes between low and middle, males' earnings per year amount between middle and high.

2.2 Results

The quantitative data were analyzed by bivariate correlations, as well as uni- and multivariate analyses of variance with a level of significance set at 5%.

Aging Concepts. First, we examined the influence of age and gender on the positively and negatively connoted images of aging. Second, the influence of participants' economic status as well as their opinions about the relevance of healthcare, social integration and self-reliance in life in old age was analyzed.

The active attitude characterizing positive connoted image of aging was found to be influenced by gender ($F(1,98)=4$, $p<0.05$) and economic status ($F(2,98)=3.9$, $p<0.05$). Women ($M=29.5$, $SD=3.1$) reach slightly higher average values than men ($M=29.1$, $SD=3$), when judging positive aspects of older age. Similar patterns are valid for people with rather higher annual incomes. No main effect of age itself was found in this regard, suggesting that across the age groups a positive attitude towards aging in general exists. However, age in interaction with gender ($F(2,98)=4.6$, $p<0.05$) and combined with economic status ($F(4,98)=4$, $p<0.05$) revealed that older women as well as the oldest respondents with medium annual earnings have the most positive vision of aging. In addition, a significant interaction effect of gender and economic status ($F(2,98)=3.5$, $p<0.05$) showed that the biggest difference in positive perception of aging emerges by participants with the highest average income per year, whereby female respondents reach higher scores in comparison to males. Especially gender ($F(1,98)=3.9$, $p<0.05$) significantly impacts the rather pessimistic vision of aging, showing that women are on average less negative towards aging than men. Age ($F(2,98)=2.4$, $p<0.1$) and economic status ($F(2,98)=2.6$, $p<0.1$) play only a marginal role, but the interaction of these variables results in a highly significant effect ($F(4,98)=4$, $p<0.01$): for older and middle-aged groups, the negative attitude towards aging decreases with increasing annual earnings. In contrast to that is the result that the higher the youngest participants' average income per year the higher their passive and abandoning attitude towards aging.

A further step in the analysis of aging concepts refers to respondents' idea of (high) quality of life. For a better overview we clustered the items of this scale in three categories (self-reliance, social integration, health monitoring) and evaluated them as self-contained variables. A multiple analysis of variance revealed a significant effect of gender ($F(3,116)=2.9$, $p<0.05$) but no relevant influence of age in this regard. According to this result in context of high quality of life, female respondents – independently of age – reported to attach more importance to be self-reliant, socially well integrated and to monitor regularly their health parameters at old age in comparison to male participants.

Effects on Medical Technology Acceptance and Interrelations with Aging Concepts.

In addition, the influence of independent variables on respondents' perceived usefulness of medical assistance technologies (dignity and independence, quick help in case of emergency, possibility to stay away from in-patient nursing care facilities) was examined. The analysis revealed an effect of age ($F(6,234)=2.5$, $p<0.05$), which became even stronger ($F(6,214)=2.8$, $p<0.05$) when economical status was added as a covariate ($F(3,106)=3.4$, $p<0.05$) into statistical calculations. A relevant impact of gender was not found. The descriptive data are illustrated in table 1 on the left.

Table 1. Descriptive statistics (means and standard deviations) of three age groups for usefulness of medical technologies (left) and interrelations with aging concepts (right)

Acceptance	Age group	M (SD)	SR	SI	HM	PI	NI
dignity and independence	Young	3.7 (1.1)	.17	.37**	.47**	.35**	.21*
	middle-aged	3.7 (1.2)					
	Older	3.9 (0.9)					
staying away from in-patient nursing care facilities	Young	4.2 (0.8)	.10	.25**	.27**	.33**	.10
	middle-aged	3.9 (0.9)					
	Older	3.9 (0.8)					
quick help in case of emergency	Young	4.4 (0.7)	.01	.27**	.32**	.32**	.10
	middle-aged	4.0 (0.9)					
	Older	4.2 (0.6)					

*p < 0.05; **p < 0.01

According to table 1, the opinions about usefulness and at the same time acceptance of medical assistance technologies are in general highly pronounced reaching least 3.7 out of the maximum possible 5 points. Additionally, intercorrelations of research variables (table 1 right) show that acceptance in terms of perceived usefulness is – with the exception of self-reliance (SR) – associated highly significant to the examined aging concepts social integration (SI), health monitoring (HM) as well as with positive (PI) and partially negative aging images (NI) showing positive correlations up to $r = .47$.

3 Study 2

The second study aims to determine whether gender differences exist concerning the acceptance of a specific medical device – a smart robot [12].

3.1 Method

Participants. A total of 280 respondents volunteered to take part, with an age range between 14 and 92 years of age ($M = 46.7$), including 149 women (54 %). Participants were recruited by newspaper advertisements and through the authors' social network.

Questionnaire. At the beginning participants were introduced into a medical scenario that was tested in terms of understandability before main data collection began: "Imagine that in the year 2025 a vast majority of people in our societies are 65 years and older [...]. Yet, there are already mature technical developments, which enable continuous medical care at home. One example for these developments is a so-called smart robot. Smart robots are able to support people with their daily work at home by e.g. taking things in the household or controlling the lights and heaters. The robot also offers a video telephoning function [...]. In case of emergency the robot is able to send a signal to the attending doctor [...]."

Variables. In order to assure a high measuring quality, reliability of the (latent construct) scales was analyzed prior to testing. All items were to be confirmed or denied on a four-point Likert-Scale from 1 (totally disagree) to 4 (totally agree).

Independent variables: Independent variables are the biological gender of participants and their age. As there are several important variables that could potentially confound gender differences, we assessed mediating factors like technical expertise (TE) and attitude towards technologies (AT). TE as well as AT reached Cronbach’s Alpha values ranging from .70 to .80 suggesting acceptable reliability.

Dependent Variables: Dependent variables were the perceived usefulness of the robot and the intention to use it if necessary (table 2).

Table 2. Items for the Intention to Use (IU) (1 = totally disagree to 4 = totally agree)

Using the medical device... (robot) ($\alpha = .92$)
... would increase my life contentment and satisfaction
... allows a sensible medical care
Can you imagine to use the device to...
... live longer independently at home?
... facilitate your living conditions?

Usefulness was assessed by usage motives (UM) and usage barriers (UB):

Table 3. Items for usage motives and barriers (1 = totally disagree to 4 = totally agree). “Under which conditions would you use the robot?”.

I would use the robot ($\alpha = .90$)
... in order to save caring costs
... in order to escape from the indignity of being cared
... in order to keep independency
... because I can turn him off
No, I would be reluctant to use the robot ($\alpha = .86$)
...because I fear the robot is not reliable
...because others would come to know about my health status
...because I do not want to be dependent on a technical device
...because I fear high costs for acquisition or maintenance

3.2 Results

Results were analysed by ANOVA - procedures (differences between gender groups) and bivariate correlation analyses (Pearson). In a further step we used regression analyses to examine the acceptance patterns and the role of gender.

Gender Differences. The descriptive statistics (means and standard deviations), categorized by gender, and intercorrelations of the constructs as well as intercorrelations with age are given in Table 4. ANOVA analyses revealed that women and men differ in their attitude towards technology and their technical experience significantly ($p < 0.05$). Men reported higher scores on both factors revealing a more positive attitude and a higher technical experience. Age showed significant negative correlations with all constructs except the usage barriers (UB), meaning that with increasing age a positive attitude as well as technical experience and a positive evaluation of the robot decreases.

Table 4. Descriptive statistics and intercorrelations of research variables in study 2 ($N = 280$)

	Women		Men		Gender	Age	AT	TE	UM	UB	IU
	M	SD	M	SD							
AT	2.80	0.41	2.96	0.41	-.18**	-.26**		.44**	.27**	-.35**	.27**
TE	3.10	0.72	3.56	0.54	-.33**	-.49**	.44**		.21**	-.21**	.24**
UM	2.99	0.80	2.98	0.65	.01	-.21**	.27**	.21**		-.41**	.72**
UB	2.36	0.64	2.30	0.63	.05	.12*	-.35**	-.21**	-.41**		-.47**
IU	2.82	0.84	2.79	0.79	.01	-.29**	.27**	.24**	.72**	-.47**	

$p < 0.05$; ** $p < 0.01$

Impact of Gender on the Intention to Use (IU). Multiple linear regressions were used to analyze the hypothetical relationships. We analyzed the data separately for men and women to get a deeper insight into gendered acceptance patterns. Age was introduced for both groups as a moderating variable, because results from the first study as well as results described in table 4 indicated that age plays an important role in the evaluation of medical technologies.

Regression analysis revealed that women's intention to use the robot is influenced by usage motives (UM), usage barriers (UB), and age, while men's usage intention is predicted by usage motives (UM), usage barriers (UB), and attitude towards technologies (Table 5). Factors explained about 60% of variance in the intention to use of the women group and 54 % of variance for the men group.

Table 5. Regression models for men's and women's intentions to use the robot

Predictor	Women		Men	
	Adj. R^2	β	Adj. R^2	β
	.60		.54	
TE		-.09		.08
UM		.61**		.59**
UB		-.22**		-.16*
AT		-.11		-.16*
Age		-.18**		-.07

* $p < 0.05$; ** $p < 0.01$

4 Discussion

The specific research objective presented in this paper was to get further insights into the acceptability of medical technologies. Considering that health related matters mainly concern elderly people, and, on the other hand, that technical development in medical context advances at a quick pace, it seems necessary to understand how people perceive and cope with the old age, and how this phenomenon is related to acceptance of modern health monitoring devices. Two studies were conducted examining the impact of user diversity (gender, age and economic situation) on aging concepts and the role of the different aging visions (positive vs. negative) for perceived usefulness of medical technologies in general. Also, the influence of user diversity on the intention to use a concrete high-tech device (smart robot in a home environment) was under study.

Overall, we learn that women take aging more positive or, in other terms, less negative than men. Also, females report to attach more importance to be self-reliant, socially well integrated and to control regularly the health condition at old age. Yet, the opinions are moderated to a greater or lesser extent by the financial situation and by persons' age. Though, gender differences in aging concepts disappear in relation to perceived usefulness of medical technologies. Here, it is rather aging itself, which determines the judgments. Either way the questioned aspects of acceptance concerning dignity and independence, quick help in case of emergency and the possibility to stay away from in-patient nursing care facilities in older age seem to be important to all respondents – as it is visible in the high descriptive scores – independent of gender, solely they seem to be variable accented in different periods of life. But can we take it for granted for all medical technologies and in all situations people are urged to use them?

In contrast to the general acceptability, a somewhat different picture emerges when evaluating more concrete technical devices. The results of the second study revealed that gender plays an important role by forming underlying structures of acceptance. Although we did not detect gender differences regarding the reported usage intention of the robot – both gender groups showed alike to the first study a relatively high usage willingness – significant differences appeared in analysis of technical experience and attitudes towards technologies. Women tend to have a less positive attitude than men. These findings and even the higher technical experience of men are in line with prior research in this context [11]. Furthermore, regression analyses revealed also different structures of factors predicting the intention to use smart robot of men and women. Whereas for both groups the usage motives as well as the usage barriers play an important role for explaining intention to use, for men the attitude is also significant. In contrast, acceptance patterns of women are moderated by the effect of age. It seems, as if there is a greater difference in the structure of acceptance between younger and older women than it is within the group of men.

These results suggest two different conclusions: one is that according to a high general acceptance people tend to welcome medical technologies per se and see many advantages in their usage, the other is that the intention to use for women is different from the structure of men's acceptance and show that formation of acceptance patterns is gendered when focused on a concrete device.

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