Smart Clothing.

Perceived Benefits vs. Perceived Fears.

Anne Kathrin Schaar, Martina Ziefle
Communication Science, Human Technology Centre (HumTec)
RWTH Aachen University; Theaterplatz 14, 52056 Aachen, Germany
{schaar, ziefle}@humtec.rwth-aachen.de

***Abstract* — Smart textile technologies integrate computer functionality into textiles. Since a few years, smart clothing has been coming up in the sport and health sector and is increasingly implemented in everyday objects within private spaces. Especially the use of textiles for medical reasons and their potential use within Ambient Assisted Living-Concepts (AAL) make it necessary to understand users' perspectives on these technologies and the willingness to use them. Today, the understanding in which way individual attitudes and emotional and cognitive abilities, may impact the acceptance of pervasive health care technologies, is restricted. This research is focused on the users' hopes and fears towards smart clothing and examines perceived benefits and barriers. As women have a higher life expectancy and will dominate the group of old people in the future – gender was chosen as one central factor of interest. As the second factor we examined technical experience in order to learn if the acceptance for smart clothing is connected to the degree of users previous experience with technology. Outcomes revealed both factors -- gender and technical experience -- to be decisive factors for the acceptance of smart clothing. Generally, women and persons with low technical experience show considerable caveats towards the usage of smart clothing technologies what becomes most evident in the perceived barriers and fears connected to the usage of this new technology.**

Keywords – Gender, Self-concept of Technical Expertise, Acceptance, Wearable Computing, Ambient Assisted Living, Pervasive Computing.

I. INTRODUCTION

As the population is getting older and older and the number of caregivers continuously smaller, there is an enormous about solutions to compensate the supply gap in the care of older persons. One of the most promising concepts represents the implementation of medical technology within private homes, enabling older and/or frail need people to stay as long as possible at home while being medically cared and monitored. Within the last years a variety of new healthcare concepts for supporting users in technology enhanced environments have been developed. These so-called pervasive healthcare applications open up new possibilities for supporting diagnosis and therapy, by bridging temporal and spatial gaps between patients and physicians. Recent information and communication technologies (lCT) enable autonomous and unobtrusive collection of clinical data and support the continuous transmission of physiological information between patients and remote healthcare providers.

Especially in the context of ambient assisted living there is a wide range of technology approaches that supports healthcare [1]. Technology can be implemented into our homes [2] [3] [4] [5]. By means of smart phones, smart textiles or other everyday objects [5] [11][14] [17] [19] [25] electronic services in different application areas (ICT, medical technology) can be delivered anytime and everywhere.

The concept of wearable computing is one aspect of these new healthcare applications. The smart clothing approach integrates computer functionality into clothing. This can imply a huge relief for chronically ill or old people, because it can replace a number of other mobile devices, which are necessary for their medical care. Today we know a lot about technical feasibility and implementation of these technologies [4] as well as economic and legal constraints of the rollout process [6]. In contrast, only little is known about the users' perspective, the acceptance of these technologies and arguments as well as the cognitive and emotional evaluations underlying the users' perspective [12] [13]. In addition, users' of these modern technology are characterized to a large extent by diversity: social norms, values, gender roles, education and technology experience considerably impact the attitudes towards new technology concepts and should be carefully studied in order to shape a user-centered technology development and diffusion [5].

II. TECHNICAL APPROACHES OF SMART CLOTHING

Smart clothing represents one promising approach within pervasive healthcare systems. Instead of additional mobile devices, which have to be intentionally taken the concept of 'wearable computing' envisions computers to integral parts of our everyday clothing [13]. The goal is to have an always-on and networked computational artifact that assists mobile users a wide range of everyday situations. Smart textiles can collect different vital parameters, which can be delivered by WLAN to patients' smart phone or computer, the doctor or even central emergency stations that calls the ambulance if necessary [15].

In the last years a considerable number of approaches, in which communication and sensor technologies are integrated into clothing, such as shoes [16] shirts [17] [18] and belts [19] as well as jewelry [20] or wristwatches [21].

In the context of smart shirts, the most popular approach the Vivo Metrics Life Shirt [22], which is marketed in the USA since 1999. This shirt is equipped with sensors that are able to measure heart and pulmonary as well as other vital values. This

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shirt has additionally the option to provide the medical data via Internet to a monitoring station where data is analyzed. Other approaches are based on fun and hedonic aspects (Wildshirt, [23]), communication aspects (O'Neill "the Hub" [24]) or sports (Falke EKG Shirt) [25].

III. MOTIVATION AND GOAL

Considering that pervasive health care and new smart technology approaches may be a promising solution for the home care of old and frail people from a medical technology point of view, the complexity of such systems raise fundamental questions of behavior, communication and technology acceptance. A first factor in this context is the heterogeneity of group of older adults [5] [10]. Different from older users in earlier times, though, today's and future older users have a higher education, a higher financial status and a basic experience with ICT. Additionally we have to expect a clientele with high demands on quality, design, usability aspects of (medical) technology as well as on the home environments and situations in which they are willing to use the relevant devices or not [14] [26] [27] [28]. Second, the group of ill people is at least as heterogeneous as the group of old people. A third factor that should be considered in this context is that smart clothing as a medical device may have some special characteristics in comparison to other medical devices: it is very close to the body and enters private spheres. Also, clothes are usually a mean of expression for many persons and it is not clear whether the medical functionality integrated in clothes are accepted at all. Other characteristics of textile technologies, which could impact acceptance might be cleaning/hygiene aspects, design, wearing comfort and skin compatibility.

Concluding, there is a major need to understand in which way emotional and cognitive attitudes, caused by individual learning histories and health states, may impact the usage and acceptance of smart textiles. This study therefore examines acceptance of smart textiles and explores the pro-using and contra using arguments. Among the individual factors, the impact of gender and the previous experience with ICT and medical technology on acceptance of smart textiles was in the empirical focus. Four major questions were guiding the exploratory study:

1. Is the acceptance for smart clothing impacted by gender?
2. Is acceptance for smart clothing impacted by the previous technical experience?
3. What are the main hopes and fears in the context of smart clothing?
4. Are there correlations between the individual factors (gender, technical experience) and the main pro- and contra using arguments?

IV. METHOD

In order to investigate a large number of participants and to take the diversity into the group of future users, the questionnaire method was chosen. We delivered the questionnaire in a paper and an electronic version. The questionnaire method was used in combination with a scenario technique, which introduced the participant into the medical context smart clothing can be used in.

Before administering the questionnaire it was revised by a sample of differently aged adults and by an expert with respect to issues of comprehensibility and wording of items.

Working on the final version of the questionnaire took between about 20 minutes.

A. Variables

As *independent variables* participants' gender and their previous experience with using technology were taken into consideration. *Dependent variables* are pro and con using smart clothing arguments (Table III, IV).

B. Questionaire

The questionnaire is based on discussions in focus groups, were carried out prior to this questionnaire study. The goal of the focus groups was to gather general opinions and perceptions regarding medical technologies for home care – in the first instance technology in general, but with special emphasis on medical devices and systems.

Within the focus group session, persons of a wide age range (n = 15, 20-65 years of age) were first introduced into smart textiles. In a second step they were requested to collect pro- and con-using arguments and to discuss the perceived usefulness of this kind of medical technology. Outcomes were collected and classified and formed into questionnaire items.

In the first section of the questionnaire demographic data (gender, age, health status and health-related behavior) was collected. Second, the technical experience and participants' self-concept of technical ability and interest were assessed. Regarding technical experience, participants reported the familiarity and frequency usage of ICT (smart phones, computers, Internet) as well as of medical technology (blood sugar meter or scale). In addition, we explored participants' interest and general attitudes towards technology (Items can be found in Table 1).

TABLE I. INTEREST IN TECHNOLOGY AND GENERAL ATTITUDES TOWARDS TECHNOLOGY

Interest and general attitudes towards technology Likert scale: 1 = very low to 6 = very high
My technical interest is…
My enthusiasm for technology is…
My technical literacy is…
My ability in dealing with technology is…
My distrust against technology is…

The second part of the questionnaire begins with a medical scenario, in which participants are introduced with the usage of smart textiles. The scenario was as follows:

> *"Imagine you were fallen sick with a heart disease and are increasingly depending on a continuous monitoring of vital parameters. A new technology makes it possible to integrate medical technology into everyday clothes (f .ex. a shirt). This technology encloses sensors that are able to check your*

heartbeat and other vital parameters permanently. That makes your clothing become a medical device. The device is able to send body parameters wireless to your smart phone, computer or even a medical emergency centre that calls the ambulance if necessary."

The scenario is followed by two items blocks – the willingness to use smart clothing if necessary (contrasting pro and con using arguments). Within each block, items are related to seven categories (extracted from outcomes of the focus groups): *monitoring, reliability, disease management, ease of use, social effects, financial aspects and design aspects.*

In Table 2, the arguments in favor of using the smart shirt (pro-using arguments) are given. Accordingly, in Table 3 the perceived barriers (con-using arguments) when using the smart shirts are listed.

The majority of the pro arguments have a direct counterpart in the con item set, as previous results of acceptance research [14] [28] revealed that an affirmation to a pro- using argument (e.g. I feel save if my vital data is permanently monitored) does not automatically mean the negation of its "con" counterpart (e.g. I do not want to be monitored continuously).

TABLE II. PRO USING ITEMS SET WITH FOCUS ON THE FOLLOWING CATEGORIES: MONITORING, RELIABILITY, DISEASE MANAGEMENT, EASE OF USE, SOCIAL EFFECTS, FINANCIAL ASPECTS AND DESIGN ASPECTS.

Arguments militating in favor of using the smart shirt Likert scale: 1 = total confirmation to 6 = total rejection
I feel save, if the smart shirt monitors my vital data permanently.
I would use it as I assume that the smart shirt is technically reliable.
I would use smart clothing, even when it is still in the testing phase.
I think smart clothing helps me managing my disease in everyday life.
I would use it when there is an easy instruction manual for smart clothing.
I think it is valued positively by others, when using I use the most recent technology for disease management.
I would use the shirt if there are chick and fancy designs available.
I would use it as the medical technology is inconspicuous.
I would not hesitate to make an investment to get a smart shirt.
I would use it if the public sickness funds pays for it.
I think smart clothing could save unnecessary trips to the doctor.
I would use the device, if my health state makes it really necessary.
I would use smart clothing immediately.
I would use smart clothing if there were no other alternatives.
I would use smart clothing, even if there would be objections of my friends.
I would use it if the smart shirt relies on a quality seal.
I would use smart clothing, if I could clean it at home by myself without efforts.

At the end of the questionnaire, participants were requested to indicate which of both, the expected benefit by invasive medical technology (pros) or the perceived shortcoming (cons) are more decisive for their overall acceptance.

From a psychological point of view, having many pro-using arguments, which militate in favor of using a specific technology, does not prevent us from having many con arguments at the same time [13] [29]. However, coping styles differ greatly across persons [30] as well as individual risk behaviors [31], which shows considerable gender differences. Therefore, it is likely that persons also differ with respect to the question, if acceptance for smart clothing technologies might be controlled by the pro-using argument and the expected benefit or, rather, by the feared disadvantage and the con-arguments, respectively. A final consideration thus addresses the question if women and men apply the same decision criterion, which of both – the positive or negative side (main pro-using argument vs. main con-argument) is more decisive for their overall acceptance.

TABLE III. CON USING ITEMS SET WITH FOCUS ON THE FOLLOWING CATEGORIES: MONITORING, RELIABILITY, DISEASE MANAGEMENT, EASE OF USE, SOCIAL EFFECTS, FINANCIAL ASPECTS AND DESIGN ASPECTS.

Arguments militating against using the smart shirt Likert scale: 1= total confirmation to 6 = total rejection
I feel controlled, if my vital data is permanently recorded.
I fear that the technology is not yet technically matured.
I am afraid of inaccurate measurements.
I suppose that dealing with smart clothing is complicated.
I do not want to use devices with a difficult instruction manual.
I fear to make unintentional mistakes while wearing smart clothing.
I would be afraid of engendering negative reactions among my friends.
I try to avoid medical devices that give the image of disease.
I expect high costs of acquisition.
I fear that using the technology limits my mobility.
I generally reject using the device even when I am ill.
I do not want to spent my spare time on disease issues and that is what I expect when using the smart shirt continuously.
To my perspective, medical technology is impersonal and I do not want to miss the personal contact with my doctor.
I do not want to use still more technical devices, as we are flooded by technical devices anyway.
I do not want to be constantly reminded by using medical devices that I am ill or frail.
I do not want to loose the connection to my body, if the smart shirt is autonomously overtaking too many tasks for me.
I do not think that smart clothing could be cleaned easily.
I fear that the technology could leave their marks on my body.
I fear physical harms caused by the smart shirt's possible technical defects.

C. Participants

A total of N = 100 participants took part in the questionnaire study. Respondents had a wide age range between 19 and 75 years (M = 43.9, SD = 16.9). Younger participants were either university students of various academic fields or persons being in vocational training. Other respondents were reached by advertisements in local newspapers. Participants reported to be in a good state of health: 72.3 % of the young group confirmed to be in a very good to good health status as well as 65.7 % of the middle aged participants and 48.3 % of the old group.

Regarding the gender distribution, 54 respondents were female (M = 42.4 years, SD = 14.8) and 46 male (M = 45.6 years, SD = 18.8). Male and female participants did not differ

within reported health states (n.s.), the frequency of visiting the doctor per year (n.s.) and educational levels (n.s.).

With regard to the technical experience, the sample was divided (median split) into two groups with different extent of technical experience: one group having a high technical experience and the other having a low technical experience.

V. RESULTS

Results were analyzed by ANOVA-procedures. The level of significance was set at 5%. For all analyses reported, we focused on differences between males and females and on the comparison of respondents with a high vs. low technical experiences on the acceptance (perceived benefits and barriers) of using a smart shirt.

A. Gender: perceived benefits vs. fears

Perceived benefits: A first analysis was to assess the overall impact of gender on the pro-using arguments (taking all items together). Overall, no significant influence of gender on the perceived benefits could be revealed, showing that men and women do not have different arguments in favor of using smart shirts. When focusing on the single items however, gender effects were found: Women report a significantly lower trust ($F(1,81) = 6.3$; $p < .05$) in the perceived technical reliability of the shirt and therefore show a lower confirmation to use the shirt (women: M = 3.2; SD = 0.9; men: M = 2.6; SD = 1.0) ("*I would use it as I assume that the smart shirt is technically reliable*").

The higher level of distrust in the reliability of smart textiles is supported by the fact that women reported to be significantly less open ($F(1,81) = 8.5$; $p = .005$) towards smart clothing in terms of using it immediately ("*I would use smart clothing immediately*"; women: M = 3.5; SD = 1.2; men: M = 2.7; SD = 1.2). In addition to the higher level of distrust and the lower willingness to use this technology promptly, women seem to be under a higher level of social pressure in their decisions-making process: They indicate to be less willing to use smart clothing, if their social network/environment would object the technology ("*I would use smart clothing, even if there were objections of my friends*", $F(1,81) = 5.5$; $p < .05$; women M = 2.8; SD = 1.2; men: M = 2.3; SD=1.0).

Overall the pro-using arguments are to a large extent gender insensitive. Specifically, there were only single gender effects: men report to be more opened to the usage of smart textiles, to be less impressed by objections by others and indicate to be willing to use this new technology immediately.

Perceived barriers/ fears: In the context of perceived fears the picture is more pronounced. When comprising all con-using arguments, there was a significant overall gender effect ($F(19,68) = 2,1$; $p = .012$). Generally, women have a more negative attitude towards using the smart shirt and showed a higher confirmation to the contra-using arguments in contrast to male respondents.

In Table 4, the descriptive values for the single items are given. In comparison to the male group, women expect an immature technology and therefore would reject to use smart textiles *("I fear, that smart clothing is not yet technically matured enough*", $F(1,86) = 6.3$; $p < .05$). Also women assume to a significantly higher extent than men that technical measurements are inaccurate *("I am afraid of inaccurate measurements",* $F(1,86) = 16.0$; $p = .000$). In addition to women's higher level of distrust against smart clothing technology, women are more afraid that the handling of the smart shirt would be complicated (*"I suppose that dealing with smart clothing is complicated",* $F(1,86) = 5.2$; $p < .05$). In addition to that, women – in contrast to men- would not use the smart technology when the instruction manual is too difficult to use *("I do not use devices with a difficult instruction manual"*, $F(1,86) = 8.8$; $p < .005$). Also, women have the expectation that they would make unintentional errors when using the smart shirt *("I fear to make unconscious mistakes while wearing smart clothing"*, $F(2,86) = 5.3$; $p< .05$).

The fears concerning ease of use of use and distrust against smart clothing technologies are supplemented by female respondents' fears of expected danger for the body *("I fear that the technology could leave their marks on my body"*, $F(1,86) = 8.7$; $p < .005$) or physical harms caused by technical defects ("*I fear danger for my body caused by technical defects*", $F(1,86) = 11.2$; $p < .005$).

Finally there are two aspects left that provoked women's higher objection to use smart clothing: Women report to be more afraid of being controlled by the technology, when the shirts records their data permanently ("*I feel controlled, if my vital data is permanently recorded*", $F(1,86) = 6.2$; $p < .05$) in comparison to male respondents. Another barrier for female respondents is the ubiquity and the omnipresence of technology: They would not use smart clothes as a further technical device, as they feel more strongly flooded by technology in general compared to male respondents ("*I do not want to use still more technical devices, as we are flooded by technical devices anyway"*, $F(1,86) = 4.5$; $p < .05$).

TABLE IV. DESCRIPTIVE OUTCOMES REGARDING THE CON-USING ITEMS: MEANS (AND STANDARD DEVIATIONS) CONTRSTING MALE AND FEMALE PARTICIPANTS (1 = TOTAL CONFIRMATION; 6 = TOTAL REJECTION)

Items	**Mean (SD)**	
Gender	**Women**	**Men**
too high control	**3.4 (1.2)**	**4.1 (1.4)**
not yet matured	**2.7 (0.8)**	**3.3 (1.2)**
inaccurate measurements	**2.7 (1.0)**	**3.6 (1.0)**
complicated handling	**3.3 (1.2)**	**4.0 (1.3)**
difficult instruction manual	**2.5 (1.1)**	**3.3 (1.5)**
unintentional mistakes	**3.7 (1.3)**	**4.3 (1.1)**
rejection of additional technical devices	**4.6 (1.1)**	**5.1 (1.0)**
technology marks on the body	**3.5 (1.4)**	**4.3 (1.1)**
danger for the body	**3.2 (1.3)**	**4.1 (1.2)**

Concluding the gender analysis it can be fixed that among the pro-using arguments of the smart shirt there are only marginal gender differences. With respect to the perceived barriers, gender reveals a sensible factor for the acceptance of smart textiles. Women are less opened to smart clothing technologies and reveal, in contrast to men, a number of fears which are related to the devices' perceived safety, the ease of use, the feelings of being controlled and the assumed danger for their body. In addition, the usage of smart textiles in

female respondents is more susceptible to social influences (opinions of friends). Interestingly, benefits and fears are not equally impacting the overall acceptance of smart textiles. Within the gender perspective, the perceived barriers and fears are more strongly influencing the acceptance.

B. Technical experience: perceived benefits vs. fears

In this section we look on effects of previous technical experience on the acceptance of smart clothing. In this context, the evaluations of the group with higher experience were contrasted to those of the group with a lower technical experience. First, perceived benefits are reported, followed by the perceived barriers.

Perceived benefits: Again, first, we analyzed if technical experience has an overall effect for the perceived benefits. No significant effect of technical experience was found. Nevertheless, looking at the single items, a few differences depending on the extent of technical experience were identified. Outcomes showed that persons with a high technical experience show a higher level of trust in the reliability of the smart shirt *("I would use it as I assume that the smart shirt is technically reliable"*, F (1,4.078) = 4.2; p <. 05) and are more opened to an immediate use, even if the technology is still in its initial phase (*"I would use smart clothing, even when it is still in the testing phase",* F (1,5.420) = 4.5; p < .05]. In addition, persons with a high technical experience are more willing to use the smart shirt immediately (*"I would use smart clothing immediately",* F (1,16.121) = 10.9; p < .005, Fig. 1).

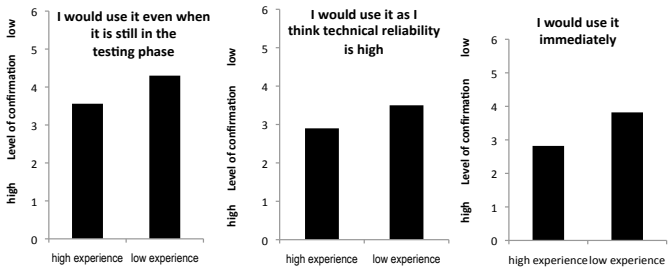

Figure 1. Technical expertise groups for the pro-using items (1 = total confirmation, 6 = total rejection)

Also, persons with a high technical experience are more willing to use smart clothes than persons with low technical experience (*"I would use the device, if necessary"*, F (1,7.05) = 8.4; p < .05, Fig. 2).

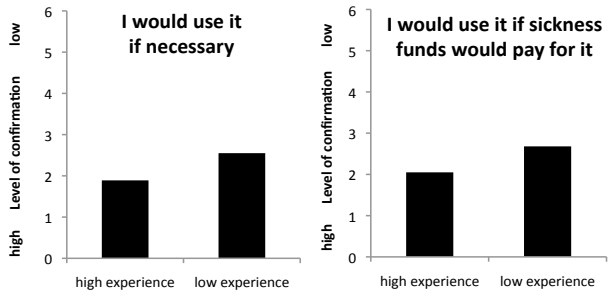

Figure 2. Mean comparison of technical expertise groups for the pro-using items (1 = total confirmation, 6 = total rejection)

Even financial support is no motivation for the low technical experience group *("I would use it if the sickness funds pay for it",* F (1,6.47) = 5.1; p < .05, Fig. 2)

Concluding this section, persons with a high level of technical expertise with ICT show a higher level of trust in smart clothing and therefore reach higher acceptance levels. They are open to an immediate usage of smart clothing, even if there is only little experience with this technology type. Apparently, the acceptance for new technologies profits from the experience with everyday IC-technologies. On the other hand, the negative effects of having low technical experience on acceptance also become evident: The information that sickness funds would pay for it does not retune persons with a low technical experience to evaluate the usage of smart clothing positively.

Perceived barriers/fears: Technical experience shows a significant overall effect on the evaluation (F (1,83) = 1.1; p < .05). The picture is quite clear: Persons with a low level technical experience (predominately women), are more skeptical about this smart clothing technologies in comparison to persons with a high level of technical experience.

The acceptance differences between both experience levels groups can be related to three dimensions: *distrust in reliability of the technology /ease of use; danger for the body and rejection caused by other reason*s. Descriptive values for all items are listed in Table V.

TABLE V. EVALUATION OF CON USING ITEMS: MEANS (AND STANDARD DEVIATIONS) CONTRSTING TECHNICAL EXPERIENCE GROUPS (HIGH LEVEL OF EXPERTISE AND LOW LEVEL OF EXPERIENCE) (1 = TOTAL CONFIRMATION; 6 = TOTAL REJECTION)

Items	Mean (SD)	
Technical experience	**High**	**Low**
not yet matured	**3.1 (1.1)**	**2.6 (0.7)**
inaccurate measurements	**3.3 (1.1)**	**2.7 (0.8)**
complicated handling	**3.9 (1.3)**	**3.0 (1.0)**
difficult instruction manual	**3.2 (1.4)**	**2.1 (0.9)**
unintentional mistakes	**4.2 (1.3)**	**3.2 (0.9)**
rejection despite disease	**5.1 (1.0)**	**4.4 (0.9)**
Impersonal technology	**4.6 (1.2)**	**4.0 (1.1)**
rejection of additional technical devices	**5.0 (1.2)**	**4.4 (0.9)**
afraid of loosing the feeling for own body	**4.0 (1.3)**	**3.3 (1.3)**
technology marks on the body	**4.0 (1.4)**	**3.3 (1.1)**
danger for the body	**3.8 (1.3)**	**2.9 (1.1)**

Having a low technical experience is related to higher a fear that smart textiles are not yet matured (*"I fear, that smart clothing is not yet technically matured enough",* F (1,83) = 5.5; p < .05) and that measurements are not reliable (*"I am afraid of inaccurate measurements",* F (1,83) = 5.2; p < .05). Also, persons with a low technical experience assume that smart clothing provide a complicated handling (*"I suppose that dealing with smart clothing is complicated"* F (1,83) = 9.3; p < .005) and need the use of a difficult instruction manual (*"I do not use devices with a difficult instruction manual"*, F (1,83) = 11.9; p < .005). Also they are concerned that they make unconscious mistakes while wearing smart clothing (*"I fear to*

make unintentional mistakes while wearing smart clothing, F (1,83) = 11.7; p = .005]).

Additional significant differences between the expertise groups are linked to fears addressing physical threat and danger for the body. Persons with a low level of expertise are more afraid of loosing the connection to their body (*"I do not want to loose the connection to my body, if the smart clothing takes over too much responsibility"*, F (1,83) = 6.4; p < .05) and that the technology could leave marks on the body (*"I fear that the technology could leave their marks on my body"* F (1,83) = 5.5; p < .05) as well as a global danger for the body caused by technical defects *("I fear danger for my body caused by technical defects",* F (1,83) = 8.4; p = .005), in contrast to person with a high level of technical expertise. Furthermore, persons with low technical experience levels would more likely reject the usage of smart clothing even when they would be ill than participants with a higher level of expertise (*"I reject using the device despite of disease"* F (1,83) = 8.8; p < .005).

Finally it is insightful that non-technical persons assume that medical technology is impersonal and are sticking more to the traditional personal contact to their doctor (*"To my perspective, medical technology is impersonal and I do not want to miss the personal contact with my doctor",* F (1,83) = 5.0; p < .05). Furthermore, the group with low technical experience believes that technology is flooding their life in a negative way, so that they want to reject any additional device (*"I reject every additional technical device, because we are flooded by technology anyway", F (1,83) = 4.7; p < .05]*.

C. Key arguments forand against using of smart clothing

At the end of the questionnaire, respondents were asked to write down the individual key using argument/barriers and to decide which of both, the pro or the contra arguments is more impacting the overall acceptance. In Fig. 3 the key pro-using arguments and in Fig. 4 the key contra-using arguments are depicted, which were mentioned by participants (Only the first mentions were taken into account).

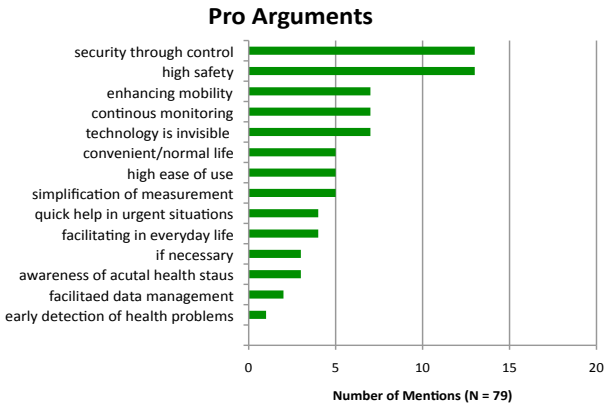

Figure 3. Main Pro Arguments for smart clothing (first mentions)

Within the pro-using arguments, 79 mentions were collected, which were classified in fifteen different categories or dimensions, respectively. On the other hand, regarding the contra-using arguments, we received 83 mentions on thirteen dimensions.

As can be seen in Fig. 3 there are two main arguments that are most prominent: *"control"* and *"safety"*. Both reached 13 mentions out of a total of 79 valid answers. Next important is the "*invisibility"/inconspicuousness* of smart medical textiles (N = 7) and *"enhancing mobility"* (N = 7) as well as *"simplification of measurement"* (N = 5), "*ease of use"* (N = 5) and the fact that smart clothing could allow a *"convenient/normal life"* (N = 5). These seven arguments cover 60 % of all pro arguments mentioned in this context.

For the contra-using arguments, we identified 12 dimensions of barriers (Fig. 4). The most frequently mentioned key barriers (out of a total of 83 quotations) were "measurement/functions errors" (N = 15), *"obstruction in every day life"* (N = 13) and *"additional costs"* (N = 12). The top group of arguments was followed by the fear that smart clothing could represent *"danger for the body"* (N = 9). Also concerns about *"cleaning problems"* (N = 7) are prevailing as well as the fear that smart clothing technologies are *"technically not matured"* (N = 6).

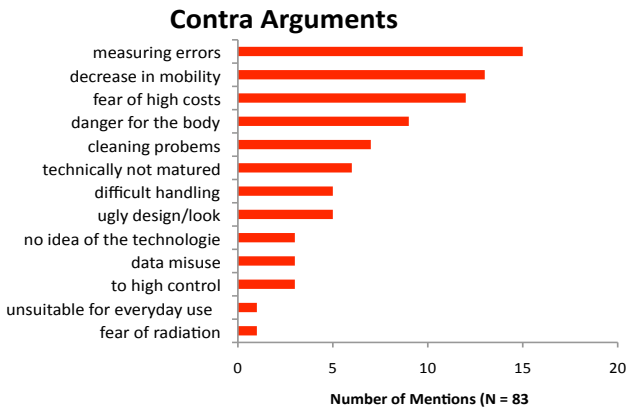

Figure 4. Contra Arguments against the usage of smart clothing (first mentions)

Interestingly, no gender differences as well as no effects of technical experience were identified on the (dis)advantages, which were mentioned as most important. Obviously, these key arguments do represent rather universal usage motives that are not modulated by these individual factors.

A final consideration addresses the question if respondents apply the same decision criterion, which of both – the positive or negative side (main pro-using argument vs. con-argument) – is more decisive for their overall acceptance (Fig. 5). Although there were no gender differences in the nature of the arguments pro or against the usage of smart clothing, a clear gender effect was found within the decision pattern. From Fig. 5., it can be seen that women show a completely different decision pattern compared to men. 42.6% of female respondents could not make a decision at all, showing a quite reluctant attitude. When focusing on the question whether women's acceptance towards the smart shirt relies more strongly on the barriers vs. the benefits, clearly more female respondents relate the overall acceptance to their fears (33.3%) compared to the positive characteristics (24.1%).

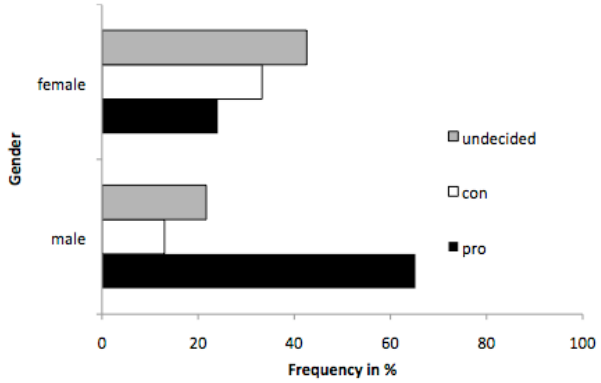

Figure 5. Decisive argument for smart clothing in the focus of gender differences

Men, in contrast show the opposite decision pattern. First of all, a significantly lesser portion of male respondents (21.7%) report to be undecided whether to be directed by the pro- or the con-using argument. Second, the majority of men (65.2%) direct acceptance to the perceived benefits of smart textiles, while only 13% of males report to be influenced by the acceptance barrier. A similar picture emerges when focusing on the technical experience (not visualized here). People with a high technical experience level are to a lesser extent undecided and prioritize the pro-argument as a basis for their overall acceptance of the smart shirt to the contra-using argument.

VI. DISCUSSION

We started our research with considering the consequences of the demographic change for the question how the medical care of frail and ill persons could be supported by new assistive technologies to be applied in the home care sector. The focus of this exploratory approach was the acceptance for medical technology implemented in textiles, taking the smart shirt as an example and to identify positive and negative attitudes towards the usage of a smart shirt. Beyond the quantitative approach, which takes the extent of confirmation or rejection into account, participants were required to name the most decisive argument for their overall acceptance. It was analyzed, whether acceptance is formed more strongly by the perceived benefits or disadvantages, respectively. In order to understand user diversity, differential effects of gender and technical experience with ICT was focused.

The outcomes can be roughly comprised along two major lines. First, both, gender and technical experience revealed to be crucial respecting the acceptance of the smart shirt. Generally, Women and persons with a low technical experience tend to be more reluctant I comparison to men and persons with a high technical experience, which appeared to be much more opened to the usage of new medical technology. When looking at the nature of the arguments, the feeling of being carefully monitored, the unobtrusiveness of the technology and the possibility to have a "normal life" despite of illness are the major perceived benefits. Regarding the nature of the barriers, the assumed inaccuracy of measurements, dependency on the technology and the thereby decreased mobility as well as risk of high additional costs are the main obstacles.

The second major outcome is that persons' acceptance is primarily formed by the assumed fears and the perceived disadvantages rather than driven by a positively connoted usage motivation, as e.g. the valuable surplus to gain independency and mobility when being ill and frail in the privacy of ones' homes. The cognitive style to prioritize negative over positive effects, revealed to be gendered: Women tend to weigh barriers more strongly, while men report that their overall acceptance relies predominately on the advantages of the smart textile technology. A deeper insight into the data shows hat this female acceptance pattern is not biased by age, but a unique pattern of the female group examined here.

These findings corroborate the gender-sensitiveness of risk-behavior [31]. Though, this gendered acceptance pattern is not restricted to the smart textile technology under study, but can also be found in other medical technologies as well: A recent study reported similar effects for invasive medical technologies [28]. One could assume that women's observed reluctance is connected to medical technologies, which are increasingly entering private spaces. However, findings from technology usage in general hint at a much more unique phenomenon: women - independently of age and technical education – seem to have a miserable technical self-concept: Women report to have a lower interest in technology than men, ascribe themselves a lower technical literacy and a lower competence when using technical devices [14] [27] [28]. Still, it seems as if the gender specific technological socialization in combination with women's perceptions of danger, safety, and intimacy are forming a gender sensitive access to smart clothing in particular and (medical) technology in general.

The findings have two major impacts: One impact is to encourage persons to frequently interact with different kinds and forms of technology, in order to develop a "natural" and "vivid" mental model of technology and to form technical literacy and handling competence at an early stage. This is especially important for female users, as they seem to be rather sensitive for fears and aloofness towards technology. The other impact is the public awareness that acceptance for medical technology is a highly fragile topic which is very much prone to fears and reluctance. What is needed is an appropriate and transparent information and communication strategy that involves users very early and specifically addresses individual concerns and expected benefits.

VII. IMPACT FOR FUTURE RESEARCH

Even though the study revealed significant results on the acceptance of smart clothing, some limitations should be considered. First it has to be taken into account that the sample under study volunteered to take part out of personal interests and seems not to be representative for the whole group of future users of medical technology. Also, the sample had a comparably high educational standard and was quite technology prone. In order to generalize the outcomes, other user groups (less educated, non-technical persons) should be

considered in future research. Second, the evaluations collected in this research were based on participants' imagination of the usage context (scenario technique). However, it is a considerable difference if something has to be evaluated that does not belong to the individual experience. Therefore, in future studies the acceptance for smart shirts have to be examined when having real experience with the wearing of smart textiles in the home care sector.

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