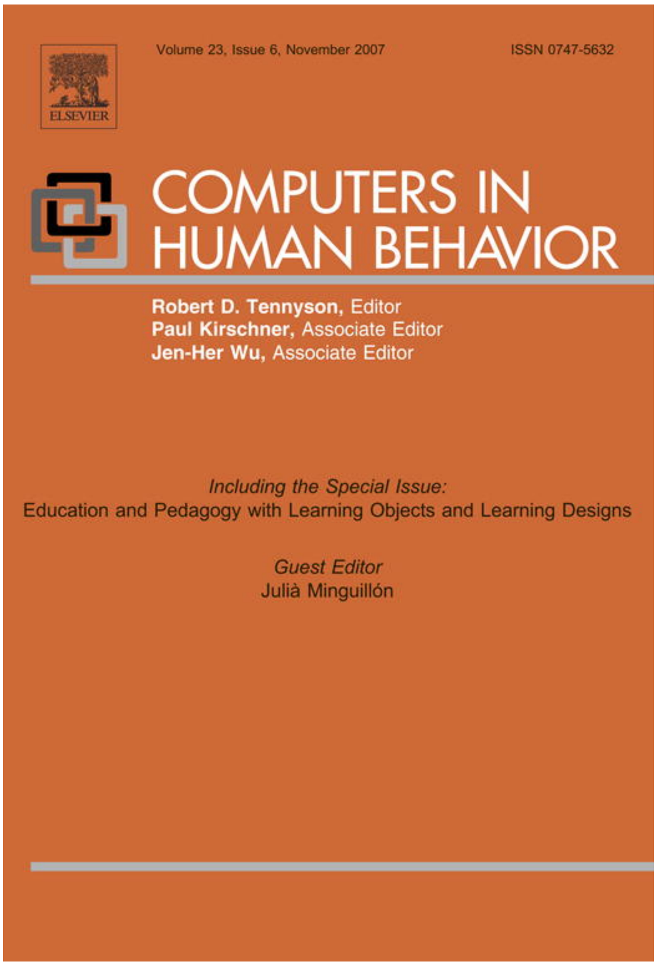
Volume 23, Issue 6, November 2007
ISSN 0747-5632
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Computers in Human Behavior 23 (2007) 2904–2927
Computers in Human Behavior
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Understanding age differences in PDA acceptance and performance

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Available online 14 August 2006

Abstract

The present study addresses two basic determinants of technology utilization: the attitude towards a certain technology and the performance when using it. According to the technology acceptance model (TAM), perceived ease of use and usefulness are assumed to be strong determinants of the actual and successful utilization of technology. However, the relationship between the acceptance of technical devices and their successful utilization (i.e. performance) is not completely understood. In this study, users' attitudes towards technology and their performance when interacting with a computer simulated PDA device were examined. Moreover, the moderating role of individual variables like age, gender, subjective technical confidence, and computer expertise in the relationship between technical performance and acceptance was analyzed. The results showed significant associations between performance and TAM factors. However, this interrelation was much stronger for the older group, especially between performance and the ease of use. The factors computer expertise and technical self-confidence played a minor role. Gender effects on technical self-confidence and TAM factors were identified, although they did not affect performance. Future research should focus on training formats for the older age group, which facilitate a successful interaction with technical devices.

Keywords: Technology acceptance; Perceived ease of use; Perceived usefulness; Technical performance; Subjective technical confidence; Age; Technology experience; Gender

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0747-5632/$ - see front matter
doi:10.1016/j.chb.2006.06.005

1. Introduction

Information technology (IT) has proliferated into most professional and private areas in the last decades. There are only a few areas left that are not permeated by IT. A prominent role in this context play mobile communication technologies, e.g. mobile and smart phones, communicators and electronic organizers, which show continuously increasing rates of growth each year (Shiffler, Smulders, Correia, Hale, & Hahn, 2005). Contrary to former times, when the utilization of IT was restricted to a sophisticated user group, nowadays broader user groups have access to IT. Moreover, the utilization of IT is no longer voluntary – its effective use has become an essential requirement in today's working and private life. The organization of professional and private activities, events and transactions heavily depends on the utilization of technical devices and demands the acceptance and application of IT from our society. However, the purchase of technical devices does not guarantee their effective utilization. Users show a broad variety of behaviors when they deal with new devices. They may completely reject them, may only partially use selected functions or they may completely adopt the technology and all functionalities offered. The central question is: What are the underlying factors causing different levels of acceptance and different reactions towards the utilization of technology? From a socio-political, psychological and educational point of view, the investigation of the nature and key factors affecting the utilization behavior of IT is important for both, research and practice.

1.1. Technology acceptance and utilization

Technology acceptance has become a key concept in a broad field of research areas, such as marketing, ergonomics, pedagogic and psychology. It can be described as the approval, favorable reception and ongoing use of newly introduced devices and systems. Regarding the concept of technology acceptance a further distinction between "attitude-acceptance" and "behavior-acceptance" was established. Attitude-acceptance includes an affective (motivational-emotional) and a cognitive component, which implies a cost-benefit-analysis of system usage. The attitude-acceptance of a user is not directly observable. "Behavior-acceptance" refers to the observable part of technology acceptance and describes the adoption of innovations by using them. In other words: acceptance contains an attitude towards a certain behavior and the behavior itself. The issues of technology acceptance, actual utilization and their mutual relationship have been researched from multiple theoretical perspectives, e.g. diffusion of innovation or social psychology.

Melenhorst, Rogers, and Caylor (2001) explain the acceptance and decision to use communication technologies in terms of a cost-benefit analysis. Not all users perceive technology as advantageous and helpful for them. Therefore, users weigh the individually expected benefits and costs (e.g. investment of money and energy, frustration while learning to use the system) before adopting a new technology.

Another approach to explain technology acceptance is the task-technology-fit (TTF) model (Goodhue & Thompson, 1995), which postulates that the acceptance of a system depends on the individual estimation of system performance. In turn, the estimation of system performance is influenced by characteristics of the task (complexity), the technology (functions) and the individual (skills and abilities). More specifically, the TTF model suggests that technology adoption depends on how well the new technology fits into the requirements of a particular task. The TTF model provides an informative basis about context- and individual variables, that might influence the issue of attitude acceptance, but it does not explain the behavior acceptance, i.e. the actual use of the system.

The most influential theoretical approach in studying the determinants of IT utilization is the technology acceptance model (TAM, Davis, 1989). Based on the theoretical assumptions of the theory of reasoned action (Ajzen & Fishbein, 1975) the TAM offers a link between technology acceptance and utilization behavior. Following the theory of reasoned action, a person's behavior is determined by the intention to perform a certain behavior. This intention is assumed to be a function of one's own attitude towards the behavior and individual norms. According to the TAM, a users' decision to use a new technical device or software package is determined by the behavioral intention to use the system. This behavioral intention is in turn determined by the perceived ease of use of the system and its perceived usefulness. The ease of use describes "the degree to which a person believes that using a particular system would be free from effort", the perceived ease of use is "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). Empirical findings showed that the perceived usefulness is the main predictor of the behavioral intention to use the system, whereas the ease of use strongly influences the perceived usefulness. Furthermore, the TAM assumes "some external variables" to influence the perceived ease of use as well as the usefulness, but neither the nature of these external variables nor their modes of functioning are described in the model. Furthermore, a rather critical assumption of this model is, that perceived ease of use and perceived usefulness fully mediate the influence of external variables on IT usage behavior. As a consequence, this assumption allows to exclude the effects of external variables, i.e. those variables related to a specific task, to system characteristics and user differences.

In the extended version of the technology-acceptance-model (Venkatesh, 2000; Venkatesh & Davis, 2000) a number of external variables was added, which were assumed to influence the behavioral intention to use a system, e.g. social and cognitive processes (subjective norm, system image and relevance, quality of output). However, even in the revised TAM the inclusion of influential external variables is not completely satisfying. Up to now, the impact of user characteristics like demographic variables (age, gender, expertise) or cognitive (abilities) and attitudinal (self-efficacy) concepts on perceived ease of use and usefulness as the main factors that influence the behavioral intention to use the system, is not adequately regarded yet. Therefore, the following section deals with the role of individual differences in technology acceptance and user behavior.

1.2. Individual differences in technology acceptance and user behavior

Individual differences such as demographic variables, computer experience, cognitive abilities and personality factors have long been important in end user computing research (e.g. Zmud, 1979). It was found that individual differences are significant factors in explaining both, technology acceptance and user behavior (Arning & Ziefle, submitted; Chua, Chen, & Wong, 1999; Gefen & Straub, 1997; Harrison & Rainer, 1992; Ziefle, Künzer, & Bodendieck, 2004). In the context of this study we refer to a key set of variables like age, computer expertise, gender and subjective technical confidence.

The factor *user age* plays an important role in the explanation of variability in system acceptance and performance. 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. Argarwal and Prasad (1999) conceptualized the factor user age as tenure in workforce, but found no significant associations to attitude variables or behavioral intentions. The question arises, if tenure is an adequate operationalization of user age. First, it does not convey information about age-related chances in physical and psychic/mental functioning and second, it does not explain individual differences in different age groups. The findings presented so far refer to older users' attitudes towards technology. Regarding performance when using a device, previous studies congruently showed that older users usually have greater difficulties in handling a computer device or in the acquisition of computer skills (e.g. Goodman, Gray, Khammampad, & Brewster, 2004). However, the knowledge about the influence of age on the estimation of perceived ease of use and usefulness as well as its relation to performance is limited.

Prior *computer experience* and its influence on attitude and performance when using technical devices has been investigated in a huge number of studies (e.g. Argarwal & Prasad, 1999; Downing, Moore, & Brown, 2005; Ziefle, 2002). Generally it was found that experts show a superior performance with respect to the utilization of technology. This finding is rather trivial as long as the relationship between computer experience, technology acceptance and performance is not completely clarified. Argarwal and Prasad (1999) found that prior experience was associated with ease of use, but did not directly affect the behavioral intention. Since Argarwal and Prasad (1999) did neither report associations between individual variables and expertise nor assessed performance measures, the relationship between expertise and individual variables, acceptance and performance is not fully understood.

Although *gender* differences have been missing a long time from IT research, they are now widely discussed as an important factor in the explanation of computer attitudes and performance. In the TAM no references to the impact of gender are found. Gefen and Straub (1997) examined gender differences in the perception and utilization of an email-system according to the TAM. Gender effects were confirmed for the TAM factors, however in a differential way: While women reported higher values of perceived usefulness, men were found to report a higher ease of use with computers. Gender differences though were not found with respect to the reported frequency of email usage, thus attitudes towards technology were not found to affect the actual use. 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) as well as a lower subjective technical confidence when using technical devices (Arning & Ziefle, submitted; Ziefle et al., 2004). 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, submitted; Ziefle & Bay, 2006). This shows – once more – that the relationship between individual variables, attitudes and performance requires further examination.

The *subjective technical confidence* (STC) is also discussed as an influential factor of technology acceptance and system usage. The STC is an individual belief in one's own ability to solve technical problems (Beier, 1999). The construct of STC has its source in the concept of locus of control, developed by Rotter (1955). The locus of control refers to individuals' generalized expectations concerning where control over subsequent events resides. The original locus of control formulation classified generalized beliefs concerning who or what influences things along a bipolar dimension from internal to external control. Internal locus of control means that individuals usually attribute success to their own competency, while individuals with an external locus of control ascribe their action outcomes not to themselves but rather to chance or others. The concept of subjective technical confidence also assumes one dimension, ranging from low subjective technical confidence (external control) to high subjective technical confidence (internal control). In comparison to other related concepts, which evaluate users' beliefs about their capacity to handle technical devices (e.g. domain-specific self-efficacy), the STC refers to a broader range of technical interactions or situations. Studies have shown that high scores in computer self-efficacy are related to navigational performance and reported ease of use (e.g. Brosnan, 1998; Liu & Grandon, 2003).

However, the selection, treatment and conceptualization of individual variables, technology acceptance and user behavior varies considerably in these studies. For example, the often-cited model of Zmud (1979) about individual variables and technology acceptance is based on a literature review without an empirical confirmation of the influence of individual variables. Moreover, the operationalization of "user behavior" was also realized in different ways. In some studies, user behavior was assessed by the rated intention to use the system or the reported frequency to use technical systems (e.g. Gefen & Straub, 1997). In other studies, measurements of performance when interacting with a system were carried out (e.g. Busch, 1995). In the context of performance measurements, effectiveness and efficiency are usually under study, evaluating different designs or measuring the influence of user characteristics on performance. However, it was found that "perceived usefulness" as the main predictor of system utilization in the TAM is poorly correlated with actual use (e.g. Straub, Limayem, & Karahanna-Evaristo, 1995), self-reported utilization or intent to use. Therefore, the TAM-variables "ease of use" or "usefulness" may not be an appropriate operationalization for the actual use, because users are poor estimators of aspects of their own behaviors (Szajna, 1996). Therefore, the actual utilization and performance when using a system should be considered in research activities.

1.3. Research model

Summarizing the knowledge so far, the perceived ease of use and the perceived usefulness of a technical device are regarded as important determinants for the acceptance and utilization of technology. Both are assumed to influence behavior intentions to use technical devices. However, prior research has reported inconsistent and incomplete results about the relationship between individual variables, attitudes and performance. The knowledge about which and how external or individual factors determine the perceived ease of use and the perceived usefulness is rather limited. This particularly applies for the factors age and gender, but also for the level of computer experience and the subjective technical confidence when using technical devices.

Moreover, quantifying performance when interacting with a device does not allow to draw conclusions regarding attitudes that may have influenced performance outcomes. Comparably few studies were concerned with both aspects simultaneously, i.e. the determination of the impact of attitudes towards technology on performance when using technology (e.g. Liu & Grandon, 2003). A second limitation – which applies to all mentioned research streams – is concerned with the fact that mainly young adults were examined in the studies. Therefore it is unknown, if the outcomes can be generalized to the older adult group which has a very different upbringing, expertise, learning history and culture regarding the utilization of technology.

Accordingly, the present study focuses on the co-acting and interdependence of participants' age, gender, expertise and subjective technical confidence, their performance when using a technical device, the reported usefulness and the perceived ease of using the device. Due to the significance of perceived ease of use for technology acceptance, it was examined, which variables contribute to the ease of use of a system and therefore, to the improvement of technology acceptance. As a technical device, an electronic organizer (personal digital assistant, PDA) was selected, a typical representative of a mobile device.

Two main research goals were pursued in this study: (1) We wanted to analyze the contributing factors to the perceived ease of use. Therefore the goal was to determine whether task performance or subjective technical confidence are the main predictors or if both variables jointly explain the ease of use. (2) In addition, by considering gender, age and the level of computer experience, we wanted to examine whether individual variables have a moderating impact on the relationship between subjective technical confidence, task performance and acceptance.

In order to structure the number of variables (individual, performance and acceptance variables), a working model was developed, which serves as an underlying framework (Fig. 1). It comprises the different variables and their hypothesized relationships. On the left hand side, the individual variables are given, which are assumed to influence subjective technical confidence, performance outcomes and perceived ease of use as well as perceived usefulness.

According to the model, the following hypotheses were specified.

H1: Individual variables such as age, gender and expertise are related to the subjective technical confidence (STC), perceived ease of use (PEU) and perceived usefulness (PUF). Young adults, male users and experts report a higher subjective technical confidence, a higher ease of use and a higher usefulness.

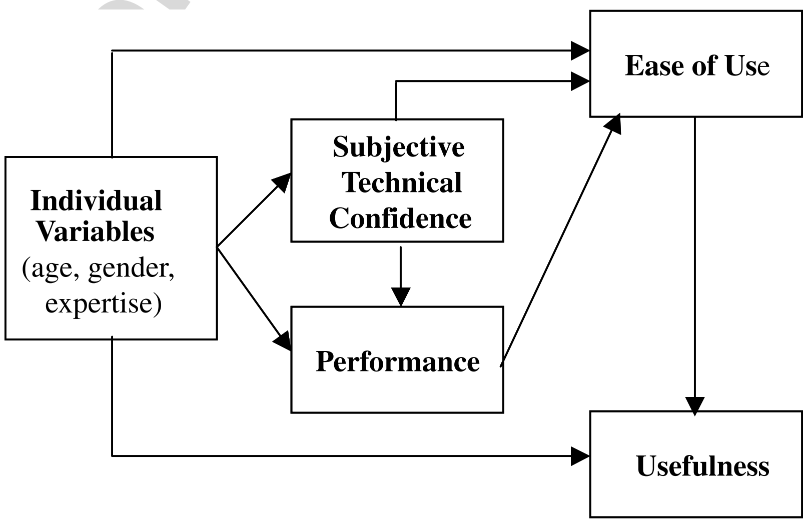

Fig. 1. Research model.

H2: Younger adults and experts perform better in navigational tasks.
H3: STC, PEU and PUF are positively associated with navigational performance.
H4: Young age, high levels of STC and performance a positively related.
H5: High degrees of STC and good navigation performance are positively related to PEU.
H6: PEU and PUF are positively related.

2. Method

2.1. Participants

A total of 32 participants, 16 young adults between 18 and 27 years ($M = 23.8$, $SD = 2.8$) and 16 older adults between 50 and 69 years ($M = 56.4$, $SD = 6.7$) took part in the study. The sample was balanced by gender with eight men and eight women in each age group. The younger subjects were recruited at the university and fulfilled a course requirement. They came from a broad range of study courses, e.g. mechanical engineering, psychology, sociology, informatics or economics. The older subjects were reached through the social network of older participants and received a small gift after completion of the experiment. All of them were active parts of the work force. In order to examine a representative sample of educational levels, a broad range of professions was covered, e.g. engineers, administrative officers, secretaries, (high school) teachers, nurses, architects, craftsmen, physiotherapists, physicians and psychiatrists. The visual acuity of participants was normal or corrected to normal and no history of eye-illness was reported. All participants were novice users of a PDA. In a pre-experimental screening, the experience with technology of both age groups was determined (see Section 2.4).

2.2. Measures used to assess attitudinal variables

2.2.1. Subjective technical competence (STC)

The subjective technical confidence, i.e. the confidence in one's own ability to solve technical problems, was measured by the STC-Questionnaire, a German test (Beier, 1999). Participants were given the short version of the test, containing eight items.

(1) Usually, I successfully cope with technical problems.
(2) Even if problems occur, I continue working on technical problems.
(3) I really enjoy cracking technical problems.
(4) Up to now I managed to solve most of the technical problems, therefore I am not afraid of them in future.
(5) I better keep my hands off technical devices because I feel uncomfortable and helpless about them.
(6) Technical devices are often not transparent and difficult to handle.
(7) When I solve a technical problem successfully, it mostly happens by chance.
(8) Most technical problems are too complicated to deal with them.

The items had to be confirmed or denied on a five-point-scale from 1 (totally disagree) to 5 (totally agree). The maximum STC-score to be reached was 40. Several studies, which assessed the reliability and validity of the STC (Beier, 1999) showed satisfactory results and proved the construct of subjective technical confidence as a technology-related personality trait.

2.2.2. *Perceived ease of use and perceived usefulness*

For the assessment of perceived ease of use (PEU) and perceived usefulness (PUF) the original items of Davis (1989) were used. The items' validity and reliability has been proven by Davis (1989) and by a number of other empirical studies (e.g. Adams, Nelson, & Todd, 1992). The items were translated to German, the native language of the participants. For each item, a five-point Likert-scale was used and participants were asked to give a response ranging from 1 (strongly disagree) to 5 (strongly agree).

2.3. *Measures used to assess user performance*

2.3.1. *Navigational performance*

Navigational performance was measured by analyzing the navigational route through the PDA menu when using the digital diary. Participants worked on two prototypic and frequently used PDA tasks. They had to enter (task 1) and to postpone (task 2) appointments in the digital diary. In order to analyze the individual navigation behavior, a Personal Digital Assistant was emulated (iToshiba Pocket PC e740, system software Windows CE), which additionally contained a logging tool to record all user actions. The PDA software simulation was run on a Dell Inspiron 8100 notebook and was displayed on a TFT-Monitor (TFT-LCD Iiyama TXA3841, 15″). The PDA-simulation exactly mirrored the real device regarding form, physical dimensions of the chassis, display size, operational keys, font size and menu structure.

All user actions were recorded online in logfiles to measure the time on task and the individual navigational route. Based on the logfiles, the percentage of successfully solved tasks (effectiveness) and time on task (efficiency) were derived as performance measures according to the standard of usability (EN ISO 9241-11, 1997). For task effectiveness, the percentage of successfully solved tasks was summed up. As efficiency measure, the time needed to process the tasks was analyzed. In order to rule out any pointing difficulties when using a stylus and to use participants' preferred input device, the tasks were completed with the computer mouse. No difficulties in mouse utilization were observed, supporting participants' self reports about their computer experience (see Section 2.4).

2.4. *Research design and procedure*

To examine the research hypotheses, an experiment with young and older adults was conducted. For the older adult group, comparably young older adults were selected, which were active parts of the work force and represent one of the major target groups of mobile technology. Each participant completed a questionnaire containing demographic questions about age, gender, educational level and study courses or profession. Furthermore, the experience with technical devices (mobile phones and computers) was assessed by requesting the length of computer and mobile phone usage, the frequency and the ease of use. The length of utilization ("For how long have you been working with ...?") was measured in years, the frequency ("How often do you use/work with ...?") was rated on a four-point Likert-scale ($1 =$ less than $1\times$ per week, $2 = 1\times$ per week; $3 = 2\text{–}3\times$ per week, 4 = daily). The ratings of duration, frequency and reported ease of computer use were aggregated multiplicatively to build the variable "computer experience". To integrate computer expertise as independent variable into the statistical analysis, a between-factor "expertise" was build. For both age groups, a median-split was conducted, respectively. Participants with "computer expertise"-scores above the median were categorized as experts, those with lower scores as novices. Moreover, the subjective technical confidence (STC) was assessed in the preliminary data collection. It was important that the STC was assessed before participants worked at the PDA-simulation in order to rule out an influence of performance on the STC-ratings. The preliminary data collection was conducted computer-based in order to familiarize participants with the experimental setting. Immediately after the preliminary data collection, participants were asked to work with the computer-simulated PDA. The experimental tasks referred to the digital diary, a standard application implemented in each PDA. In the first task, participants had to enter an appointment into the digital diary, then an existing appointment had to be postponed. A time limit of three minutes per task was set. After participants completed the experimental tasks, they were asked to rate the perceived ease of use (PEU) and the perceived usefulness (PUF) of the PDA. All participants were tested separately.

2.5. Data analyses

Bivariate correlations, univariate and multivariate analyses of variance as well as univariate and multivariate linear regressions were employed. The level of significance was set at 5%. The significance of the omnibus *F*-tests in the MANOVA analyses were taken from Pillai values. All subjects were included in the analyses, even those who did not solve the PDA tasks in the given time limit.

3. Results

3.1. Reliability and validity of scales

The reliability of the STC and the TAM measures (PEU and PUF) was assessed by scale reliability analysis. The Cronbach alpha values were 0.91 for the STC and 0.96 for the TAM. Compared to the acceptance level of 0.7 for empirical research, the observed scale reliabilities were extraordinarily high and indicated that the items for each scale were internally consistent and reliable. A principal factor analysis with varimax rotation (with Kaiser Normalization procedure) was conducted to ensure that items for the same construct measure the particular trait, while items for another construct measure a different trait. Three factors that explained 79.1% of variance in all items were extracted. The rotated factor matrix in Table 1 shows that all items loaded on the correct latent constructs (indicated by bold values). Therefore, the factorial validity of the scales can be taken for granted.

3.2. Individual variables and STC, PEU and PUF

H1 states differences in the degree of one's STC and TAM (PEU and PUF) depending on individual variables like age, gender and expertise. To confirm that, a MANOVA with the between-factors age, gender and expertise on the dependent variables STC,

Table 1
Factor analysis of the measurement scales PEU, PUF and STC

	Factor loadings		
	PEU	PUF	STC
TAM1 (PEU)	**.910**	.302	.183
TAM2 (PEU)	**.845**	.401	.141
TAM3 (PEU)	**.878**	.294	.123
TAM4 (PEU)	**.902**	.291	.198
TAM5 (PEU)	**.797**	.331	.255
TAM6 (PEU)	**.770**	.453	.193
TAM7 (PUF)	.306	**.848**	.046
TAM8 (PUF)	.404	**.753**	.005
TAM9 (PUF)	.362	**.863**	.075
TAM10 (PUF)	.384	**.815**	.080
TAM11 (PUF)	.270	**.899**	.129
TAM12 (PUF)	.183	**.890**	.211
STC1	.338	.251	**.777**
STC2	.176	.090	**.785**
STC3	.047	.408	**.788**
STC4	.526	.161	**.675**
STC5	−.059	.238	**.724**
STC6	.106	.025	**.770**
STC7	.106	−.166	**.789**
SCT8	.406	−.319	**.641**

Bold values indicate items' loadings on correct latent constructs.

PEU and PUF was conducted. Multivariate tests revealed a significant main factor of age: older adults score significantly lower in STC, PEU and PUF than younger adults ($F(3,22) = 4.7$; $p < 0.05$, Table 2).

The factors expertise and gender missed statistical significance in the overall F-test ($F(3,22) = 3.3$, $p > 0{,}05$), but the interaction of age and gender reached significance ($F(3,22) = 3.3$, $p < 0.05$). Regarding the STC (Fig. 2 (left)), young male users show a higher technical confidence ($M = 85.3$) compared to young female users ($M = 66.9$) and older adults ($M_{male} = 61.6$; $M_{female} = 61.7$). The examination of Fig. 2 (left) shows, that the interaction of age and gender is ordinal, that means, that differences in the STC only occur for young male adults. For the PEU (Fig. 2 (center)), a hybrid interaction occurs, i.e. only one – the factor age – of the two factors gender and age can be globally interpreted: younger adults ($M_{male} = 25.8$, $M_{female} = 21.1$) report a higher ease of use than older adults ($M_{male} = 13.7$, $M_{female} = 20.9$). A disordinal type of interaction exists for the PUF, i.e. none of the main factors must be interpreted (Fig. 2 (right)). The degree of perceived usefulness differs depending on age and gender: young male adults score the highest on the PUF-scale ($M = 22.8$), in contrast to older male adults, who score the lowest

Table 2
Means (and SD) for both age groups for STC, PEU and PUF ($n = 32$)

Factor "age"	STC	PEU	PUF
Young	75.3 (14.8)	23.7 (4.5)	18.6 (7.4)
Old	62.0 (14.8)	17.0 (8.2)	14.1 (6.8)

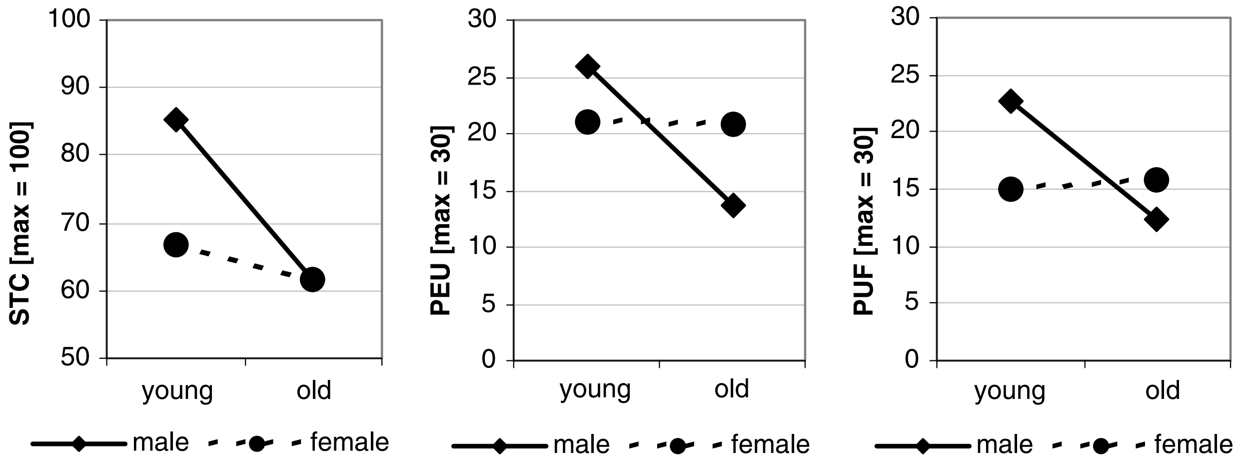

Fig. 2. Interactions of age and gender for STC (left), ease of use (center) and usefulness (right).

($M = 12.4$). For female participants, the relationship is inverted ($M_{young} = 14.9$; $M_{old} = 15.9$) (see Table 3).

Concluding the results so far, H1 is supported partially. Individual variables like age and gender influence the extent of technical confidence, ease of use and usefulness. Younger and especially male adults report the highest ratings regarding STC, PEU and PUF. Gender differences only play a role in relation to age: younger male adults reach the highest values on the STC, PEU and PUF scale. Contrary to expectations, expertise was not found to be an influential factor, neither regarding subjective technical confidence, nor for ease of use and usefulness.

3.3. Individual variables and performance

The influence of individual variables on navigation performance was formulated in H2, stating that performance is higher for young participants and participants with higher computer expertise. In order to rule out gender differences, the factor gender was included into the data analysis. A $2 \times 2 \times 2$ analysis of variance with the factors age, gender and expertise as between-subject variables and effectiveness (number of tasks solved) and time on task as dependent variables was carried out. A highly significant main effect of age was revealed in the omnibus F-test ($F(2,23) = 18.5$, $p < 0.01$): young participants solved more tasks more quickly than older participants.

The performance of male and female participants as well as novices and experts did not differ significantly. Neither for the factor gender nor the factor expertise significant effects were observed. Summarizing the results, H2 is partially confirmed: only the factor age has a considerable impact on performance outcomes.

Table 3
Means (and SD) for both age groups for number of tasks solved and Time on task ($n = 32$)

Factor "age"	Number of tasks solved [max = 2]	Time on task
Young	1.8 (0.5)	178.9 (78.5)
Old	0.6 (0.7)	321.2 (61.9)

3.4. Relationship between STC, PEU and PUF and navigational performance

To examine the positive relationship between the STC, PEU and PUF on the one hand and performance on the other hand (as stated in H3), correlational analyses were conducted (Table 4). Results reveal that STC, PEU and PUF show significant associations with time on task, indicating that a high technical confidence ($r = -.64$; $p < 0.05$), high ease of use ($r = -.69$; $p < 0.05$) and usefulness ($r = -.41$; $p < 0.05$) were related to a shorter time on task. The same pattern is obtained for task effectiveness: participants reporting a high technical confidence ($r = .58$; $p < 0.05$) and a high ease of use ($r = .72$; $p < 0.05$) are more successful in solving the experimental tasks. Perceived usefulness, in contrast, was not correlated with the number of tasks solved.

On the basis of these correlations, H2, which states a relation between attitude variables like STC, PEU and PUF and navigational performance, is confirmed. Participants, who report a highly pronounced technical confidence, ease of use and usefulness, tend to perform better in the experimental PDA-tasks. In order to determine if the correlation outcomes are present in both age groups, further correlation analyses were carried out for both age groups separately (Table 5).

Table 4
Bivariate correlations between STC, PEU, PUF and performance variables ($n = 32$)

	STC	PEU	PUF	Number of tasks solved	Time on task
STC	1	.46**	.30	.58**	−.64**
PEU		1	.67**	.72**	−.69**
PUF			1	.35	−.41*
Number of tasks solved				1	−.86**
Time on task					1

* $p < 0.05$.
** $p < 0.01$.

Table 5
Bivariate correlations between STC, PEU, PUF and performance variables for younger (top) and older adults (bottom)

	STC	PEU	PUF	Number of tasks solved	Time on task
Younger adults					
STC	1	.57*	.42	.35	−.55*
PEU		1	.57*	.52*	−.66**
PUF			1	.091	−.27
Number of tasks solved				1	−.61*
Time on task					1
Older adults					
STC	1	.23	−.05	.51*	−.51*
PEU		1	.70**	.67**	−.61*
PUF			1	.26	−.28
Number of tasks solved				1	−.87**
Time on task					1

* $p < 0.05$.
** $p < 0.01$.

The comparison of Tables 4 and 5 shows, that the relationship between STC and the number of tasks solved is only significant for the older group, whereas this relationship misses significance for the younger adult group ($r_{old} = .51$, $p < 0.05$ vs. $r_{young} = .35$, n.s.). Furthermore, a stronger association between PEU and task effectiveness for older adults is revealed: The age-group-specific correlation analyses show, that the linear relationship between individual beliefs and task effectiveness is stronger for older adults ($r_{old} = .67$, $p < 0.01$ vs. $r_{young} = .52$, $p < 0.05$).

As the multivariate and correlational analyses did not reveal any systematic relationship between expertise, individual variables, attitude variables and performance, the variable "expertise" was excluded from further analyses.

3.5. Regression analysis

So far, results show that individual variables like age and gender, subjective beliefs like STC, PEU and PUF and task performance are closely interrelated. To get a deeper insight into the relationship of those variables and to examine the research model, individual sets of multivariate regression analyses were conducted. It was of central interest to find out what contributes more to the acceptance of mobile devices like PDAs. Is objective task performance the main predictor of ease of use? Or do subjective perceptions of capabilities (STC) predict the degree of acceptance? Additionally, the – probably moderating – effects of age were of interest. In order to detect effects of multicollinearity, i.e. when predictors are correlated to each other, leading to biases in the regression model, collinearity diagnosis were carried out. As the condition index $\leqslant 10$ showed, no collinearity between the predictors was found.

3.5.1. Prediction of subjective technical confidence (STC)

As addressed before, H1 declares an association between age and gender for the subjective technical confidence. The stepwise regression analysis on STC with the variables age, gender, task effectiveness and efficiency, PEU and PUF was highly significant (at $\alpha = 0.000$): Time on task (as performance component) and gender (as individual variable) are significant predictors of the subjective technical confidence (Table 6). Interestingly, instead of age – what would have been expected – the predictor task efficiency (time on task) was included in the regression model, indicating that age alone does not have much predictive power in explaining age-related differences in the STC.

As shown in the interaction of age and gender for the STC in Fig. 2, the significant influence of gender in the regression model is caused by extremely high STC-scores of young male adults. This was proven again in the following analysis. Testwise regressions for both age groups show, that the factor gender has predictive power only for the STC of younger adults (Table 7). For older adults, time on task is the only predictor for the STC. The negative β-coefficient expresses that a high STC is associated with short processing time and vice versa.

Table 6
Regression analysis on STC ($n = 32$) (TOT, time on task)

Dependent variable	Adj. R^2	Condition index	Predictor	β	p	t-Value
STC	0.48	6.1	TOT	−0.63	0.00	−4.81
			Gender	−0.33	0.02	−2.50

Table 7
Testwise regression analysis on STC for young adults ($n = 16$) and older adults ($n = 16$)

Dependent variable	Age group	Adj. R^2	Condition index	Predictor	β	p	t-Value
STC	Young	0.62	5.7	Gender	−0.64	0.00	−3.84
				TOT	−0.36	0.05	−2.20
STC	Old	0.21	10.8	TOT	−0.51	0.04	−2.21

3.5.2. Prediction of performance

H4 claims a positive relationship between young age, high levels of STC and performance. Because performance was assessed by two variables – task effectiveness and efficiency – the regression analyses were carried out for each performance measure separately. Due to high correlations between the performance variables, one of each performance variables was excluded from the regression analyses on the other performance variable, respectively. According to the Condition Indices ⩽10, multicollinearity was ruled out for the regression models.

3.5.2.1. Task effectiveness (number of tasks solved). For the whole group of participants, the perceived ease of use and the factor age explain 68% of variance in task effectiveness ($\alpha = 0.000$, Table 8). Participants, who report a high ease of use after solving the tasks, also reached high task effectiveness.

In testwise regressions for both age groups, the predictive power of perceived ease of use is lower for younger adults ($R^2 = 22\%$) than for older adults ($R^2 = 41\%$). This indicates that the relationship between PEU and task effectiveness is weaker for younger adults than for older adults (see Table 9).

3.5.2.2. Efficiency (time on task). Focusing on time on task as predictor variable, the regression model explains 71% of variance ($\alpha = 0.000$, Table 10). The strongest predictor is age, indicating that older participants need considerably more time to work on the experimental tasks. Again, ease of use is a highly significant predictor of the performance variable. Participants with high scores on the PEU-scale are faster in the completion of the experimental tasks. For the whole group, the STC also has explanatory power, which means that participants with a high subjective technical confidence need less time to process the tasks. The integration of the STC into the regression model causes a rather high

Table 8
Regression analysis on number of tasks solved ($n = 32$)

Dependent variable	Adj. R^2	Condition index	Predictor	β	p	t-Value
Number of tasks solved	0.68	10.1	PEU	0.50	0.00	4.38
			Age group	−0.48	0.00	−4.23

Table 9
Testwise regression analysis on performance (number of tasks solved) for young adults ($n = 16$) and older adults ($n = 16$)

Dependent variable	Age group	Adj. R^2	Condition index	Predictor	β	p	t-Value
Number of tasks solved	Young	0.22	10.9	PEU	0.52	0.04	2.27
Number of tasks solved	Old	0.41	4.5	PEU	0.67	0.00	3.38

Table 10
Regression analysis on time on task ($n = 32$)

Dependent variable	Adj. R^2	Condition index	Predictor	β	p	t-Value
TOT	0.71	17.3	Age group	0.44	0.00	3.88
			PEU	−0.35	0.00	−3.07
			STC	−0.29	0.02	−2.57

Condition Index (17.3), which indicates moderate collinearity. Without including the SCT into the regression model, the adjusted R^2 is slightly reduced to 65% with an Condition Index of 9.6. Therefore, the results of this regression model (including the STC) have to be interpreted cautiously.

The age group-specific testwise regression analysis did not contribute additional information to the prediction of the variable time on task. As age is the main predictor in the regression analysis, the exclusion of age reduces the overall adjusted R^2 to $R^2 = 39\%$ and $R^2 = 32\%$, respectively. For both age groups, the perceived ease of use is the main predictor of time on task (Table 11).

Concluding the results regarding H4, the STC does not act as a predictor of performance. Thus, performance outcomes are not influenced by participants' subjective technical confidence. In contrary, age and the perceived ease of use were found to be the main predictors of performance.

3.5.3. Prediction of ease of use (PEU)

In order to examine H5, which declares the positive influence of technical confidence and performance on the perceived ease of use, a stepwise regression with the variables age, gender, performance (number of tasks solved, time on task), STC and perceived usefulness was conducted. The regression model was significant at $\alpha = 0.000$. Adjusted R^2 values suggest that task effectiveness and perceived usefulness can predict 70% of the variance in PEU. Obviously, participants correspond sensitively to their performance outcomes and the perceived usefulness when they define the ease of use of handling the device. Contrary to expectations, subjective beliefs like the STC do not affect the ease of use (Table 12).

Testwise regressions show age-specific differences in the prediction of the perceived ease of use (Table 13). For younger adults, the task effectiveness does not predict ease of use, but rather task efficiency (time on task). Apparently, younger adults do not include their success in solving the PDA tasks (effectiveness) into their judgment of ease of use. Possibly,

Table 11
Testwise regression analysis on performance (time on task) for young adults ($n = 16$) and older adults ($n = 16$)

Dependent variable	Age group	Adj. R^2	Condition index	Predictor	β	p	t-Value
TOT	Young	0.39	10.8	PEU	−0.66	0.01	−3.28
TOT	Old	0.32	4.5	PEU	−0.61	0.01	−2.86

Table 12
Regression analysis on PEU ($n = 32$)

Dependent variable	Adj. R^2	Condition index	Predictor	β	p	t-Value
PEU	0.70	5.6	Number of tasks solved	0.56	0.00	5.28
			PUF	0.47	0.00	4.45

Table 13
Testwise regression analysis on perceived ease of use (PEU) for young adults ($n = 16$) and older adults ($n = 16$)

Dependent variable	Age group	Adj. R^2	Condition index	Predictor	β	p	t-Value
PEU	Young	0.54	8.7	TOT	−0.55	0.01	−3.00
				PUF	0.42	0.04	2.33
PEU	Old	0.72	5.1	PUF	0.56	0.00	3.84
				Number of tasks solved	0.52	0.00	3.58

due to their overall good performance when working with the PDA, the effectiveness may not be relevant as an indicator. They rather rely on time on task when assessing the ease of use. In contrast, for older adults, task effectiveness plays a major role in the prediction of ease of use. Apart from task effectiveness, the main factor predicting ease of use in older adults is the perceived usefulness of the device. Probably, older adults integrate general attitudes towards the device into their formulation of ease of use. This can also be observed in the regression model for younger adults, but the perceived usefulness of the device is a much weaker predictor of the perceived ease of use for younger than for older adults.

As the STC was excluded in the stepwise regression model, which predicted the perceived ease of use, we wanted to find out how much variance of the perceived ease of use is explained by the STC alone. Therefore a regression with the STC as the sole predictor of perceived ease of use was run. Only 18.9% of variance in the perceived ease of use is explained by the STC. The picture changes however, when testwise regressions are carried out for both age groups, separately. In testwise regressions the STC was found to have a different effect on perceived ease of use depending on age. For younger adults, the STC explains 27.7% of variance, the regression model is significant at $\alpha = 0.021$. For older adults the overall R value ($R^2 = -.16$) does not even suggest a linear relationship between STC and perceived ease of use.

3.5.4. Prediction of perceived usefulness (PUF)

In order to confirm H6, which states an association between ease of use and usefulness, a multiple stepwise regression with the independent variables age, gender, STC, performance measures (number of tasks solved, time on task) and the perceived ease of use was carried out.

According to expectations, the perceived ease of use was the main predictor of perceived usefulness, with an adjusted $R^2 = 42\%$ (Table 14). The same results were found

Table 14
Regression analysis on PUF ($n = 32$)

Dependent variable	Adj. R^2	Condition index	Predictor	β	p	t-Value
PUF	0.42	5.8	PEU	0.66	0.00	4.88

Table 15
Testwise regression analysis on perceived usefulness (PUF) for young adults ($n = 16$) and older adults ($n = 16$)

Dependent variable	Age group	Adj. R^2	Condition index	Predictor	β	p	t-Value
PUF	Young	0.28	10.9	PEU	0.57	0.02	2.60
PUF	Old	0.45	4.5	PEU	0.70	0.00	3.65

in age-specific testwise regressions (Table 15). In the group of young adults and – to a stronger extent – in the group of the older adults, perceived usefulness was a significant predictor of perceived usefulness. The comparably low amount of explained variance for the group of younger adults indicates, that they might integrate further variables in the formulation of the perceived usefulness of a PDA, beyond the ease of using the device.

4. Discussion and conclusion

The aim of the present study was to analyze the relationship between individual variables (age, gender, subjective technical confidence, and expertise), the actual performance when using a PDA, and the acceptance of technology measured by perceived ease of use and perceived usefulness (based on the Technology Acceptance Model). The perceived ease of use while interacting with a technical device is regarded as an important determinant of technology acceptance.

Two research goals were scrutinized in this study:

(1) We focused on the question, if task performance or subjective technical confidence are the main predictors of perceived ease of use or if both variables jointly explain the ease of use.
(2) We examined if individual variables have a moderating effect on the relationship between subjective technical confidence, task performance and acceptance.

In order to empirically test our hypotheses, a sample of younger and older adults accomplished prototypic tasks with a simulated PDA. After task completion participants rated the perceived ease of use and the usefulness of the device. Results revealed that older adults showed a significantly lower PDA performance and also reported a lower ease of use in comparison to younger adults. The subjective technical confidence and the perceived ease of use were found to be influenced by age and gender, as young male adults scored the highest on these scales. As expected, strong associations between subjective technical confidence, ease of use, usefulness and PDA performance were found. In regression analyses we identified participants' PDA performance as the main predictor of perceived ease of use and, in turn, ease of use as predictor of perceived usefulness. Most of the hypothesized interrelations between user characteristics, acceptance and performance were confirmed. However, there were some specific findings, which contribute novel information to the current body of knowledge about the complex interaction between individual variables, technology acceptance and performance. These findings will be discussed in the following sections.

4.1. Predictors of perceived ease of use

In this study the perceived ease of use after interacting with the PDA was strongly associated with the preceding PDA performance: in regression analyses users' PDA performance was found to be the main predictor of perceived ease of use. Although we assumed that the attitudinal construct of users' subjective technical confidence would also act as a determinant in the assessment of the perceived ease of use, the STC was not included in the regression models predicting the ease of use. As found, only the direct experience of interacting with the technical system was related to perceived ease of use. Obviously, participants of both age groups refer to their recent system performance as an objective yardstick when they evaluate the perceived ease of use. This result is inconsistent with the findings of Venkatesh and Davis (2000), where a low self-efficacy of the target user group explained the rejection of a technical system. This inconsistency might be resolved, when the methodology and the assessment of user behavior are regarded in more detail. Regarding methodological aspects, it has to be considered that Venkatesh and Davis assessed self-efficacy and the intention to use the system by the same method: by user ratings. Therefore, the two variables share the same method variance, which might explain the stronger association between self-efficacy and the intention to use the system. Referring to the assessment of user behavior, the present study assessed the actual menu navigation performance as user behavior, whereas Venkatesh and Davis collected ratings of the intention to use the system. We assume that the operationalizations of user behavior in the two studies are not comparable, because Venkatesh and Davis' study refers to the non-observable pre-conditions of behavior (the intention to use the system), whereas our study is based on the observable user behavior while interacting with the device.

Thus, our findings indicate that the effect of attitudinal variables like the subjective technical confidence on the acceptance of technical devices is rather low. Instead of that, we find that the perceived ease of use of a system is significantly determined by the successfulness of performance of its users. One important implication of our findings is that technical systems should be designed in a way that promotes a successful interaction. This refers primarily to aspects of usability or training interventions that aim at an improvement of performance when using the system.

Apart from insights into the predictors of perceived ease of use, we also found strong evidence for the effect of external/individual variables, which moderate the relationship between system performance and technology acceptance.

4.2. The moderating role of individual variables

The most influential moderating individual variable was *user age*, as indicated by considerable differences in the pattern of relationships between technology performance and acceptance in the two age groups. Age-specific processes were found in the assessment of the perceived ease of use, the judgment of perceived usefulness and in the relationship between subjective technical confidence and performance.

Referring to the age-specific formation of *ease of use* both age groups refer to their menu navigation performance when they rate their ease of use, but – and this is a novel finding – younger and older adults consult different facets of performance. Younger adults refer to their efficiency, i.e. how easy and effort-free they experienced the interaction with the device. For older adults the determining factor in the evaluation of the perceived ease of use is effectiveness, i.e. the success when using a technical device. This finding has important implications for the design of training interventions. Especially the older group should experience successful interactions quite early in the learning process. Therefore, training interventions (especially regarding job-related IT-system utilization) should very early lead to perceptions of achievement and success. This aim might be achieved by tailoring tasks or learning sequences in a manageable size. Moreover, a constructive feedback regarding the tasks' success might reduce older adult's hesitancy and lack of confidence when interacting with technical devices.

Interestingly, regression analyses showed that older adults also integrated the perceived usefulness of a device in their ratings of ease of use. We assume that older adults also consider the benefits of using a certain technical device when they evaluate the ease of use. Whenever the advantages of a technical device are not transparent for users, they might invest less effort into system utilization, which might lead to higher difficulties system interaction (e.g. Melenhorst et al., 2001). Therefore the practical benefit of technical devices should be emphasized, e.g. by the management in organizations or by marketing activities.

Age-specific differences were also present in the evaluation of the *perceived usefulness*. For older adults, the ease of use played the main role in the assessment of the perceived usefulness of a technical device, whereas the perceived ease of use had a lower explanatory power for younger adults. As found in a recent empirical study (Arning & Ziefle, 2006), younger adults report further categories (e.g. the price of a device, its value as a status symbol, etc.) besides the perceived ease of use when they assess the usefulness of a device.

Furthermore, user age played a moderating role in the *relationship of subjective technical confidence and performance*. The association between STC and performance was stronger for older adults than for younger adults. Older adults with a lower technical confidence in comparison to those with a higher STC reached a lower level of effectiveness and efficiency. This relationship was weaker for participants of the younger age group, which corroborates the findings of other studies (e.g. Ziefle, Bay, & Schwade, 2006). Ziefle et al. found effects of a low STC on menu navigation performance in children, but not in a group of university students. The authors assume that the young adults might have used their high cognitive abilities to successfully solve the tasks. Comprising the results of the two studies, we assume that a less pronounced subjective technical confidence in younger adults is compensated by other factors, which allow them to reach the same performance-level as young users with a high subjective technical confidence. In order to promote the successful interaction of older adults with technical devices, the nature of these compensating factors should be explored in more detail. One possible compensating factor might be the previous expertise with similar technical devices or computers that allows the deduction and application of task-relevant concepts. Another type of compensating factor might be spatial visualization ability, which is regarded as highly important for the successful utilization of technical systems (e.g. Sein, Olfman, Bostrom, & Davis, 1993; Stanney & Salvendy, 1995). Users with high spatial visualization abilities were found to outperform users with low spatial abilities in completing computer tasks (e.g. Pak, 2001; Westermann, 1995), using hypertext (e.g. Lin, 2001) or mobile phones (e.g. Bay & Ziefle, 2003; Bay & Ziefle, under revision). Spatial visualization abilities, therefore, might play a moderating role in the relationship between subjective technical confidence and performance. Following this argumentation, high spatial abilities promote a successful interaction with technology, which in turn promotes a high subjective technical confidence. As spatial abilities decline with increasing age (e.g. Salthouse, 1992), we assume, that the age-related decline of spatial visualization abilities hampers a successful interaction with technical devices, which, in turn, affects the degree of subjective technical confidence.

However, regarding the moderating effects of user age, the findings show clearly, that it is definitively not sufficient to examine only young users' technical acceptance and performance and to generalize the results to the whole user population. The found age-specific pattern of relationships indicates that it is highly important to integrate the older user group in studies about user attitudes *and* behavior.

The study also yielded important findings regarding the moderating role of *gender*. In contrary to other studies (e.g. Busch, 1995), which postulated gender effects in the interaction with technical devices, gender showed only weak effects as a moderating variable in the examined field of technical performance and acceptance. In our findings, gender did not influence the performance outcomes in both age groups. However, gender effects were present in the subjective ratings of technical confidence and perceived usefulness. As the interaction of age and gender for the STC showed, the high STC-ratings of young male participants were the actual source of this gender effect. Their STC-ratings were about 26% higher than those of the other users. Based on our findings we assume that rather attitudinal constructs like the subjective technical confidence than the actual performance capacity are subject to gender-related effects. As higher values in subjective technical confidence are not necessarily accompanied by a better performance (e.g. Anandarajan, Simmers, & Igbaria, 2000; Arning & Ziefle, submitted), the sources of the males' higher values might reflect biases due to social desirability. Further research activities need to be conducted in order to investigate the complex relationship between gender, technical confidence and performance more thoroughly.

Contrary to expectations the user characteristic *computer expertise* showed no associations with any of the other individual variables, PDA menu performance or technology acceptance. We assume that the low predictive power of computer experience has methodological causes. Although computer expertise and its effect on performance has been studied thoroughly (e.g. Downing et al., 2005; Thompson, Higgins, & Howell, 1994), the underlying concept of expertise and its measurement are not exactly defined yet. In most studies computer experience is determined by subjective reports of length and frequency of computer use. This kind of assessment is based on the simplified assumption that expertise can be understood as a function of the time spent operating the device. Furthermore, this conceptualization of expertise leaves open what concepts or knowledge structures are acquired while interacting with the technology and also how they constitute the nature of expertise. However, it is highly questionable that the time spent at a computer automatically leads to an acquisition of computer-relevant knowledge. Therefore, instead of defining experience by the assessment of quantitative aspects (duration and frequency) of computer usage, qualitative aspects like domain-specific knowledge concepts should be assessed. In further studies, the approach of a qualitative assessment of computer expertise has to be pursued, in order to improve content validity when analyzing effects of computer expertise.

5. Practical applications

Although the complex interaction of users' attitudes and abilities on performance is not completely explained yet, the findings provide a considerable number of practical applications for training issues. One major result is that the successful interaction with a technical device is associated with a high acceptance of the device. Therefore, from an ergonomic and pedagogic perspective, it is important to visualize the success at an early stage of the learning process of system interaction. An increased perceived ease of use may in turn enhance users' motivation to interact with technology.

6. Limitations and future research

Even though the present study provided detailed insights into the co-acting of technology acceptance and performance measures when interacting with a technical device, there are some limitations that should be considered for the broader generalization and application of our findings.

6.1. The specificity of technology and experimental tasks

Strictly speaking, our results are limited to the examination of a PDA, a typical representative of mobile technologies. However, with respect to the generalization of our findings, more research activities are necessary. There are at least two important aspects that should be addressed in future studies:

(1) *Device-specificity*. Further research will have to show whether the ease of use and the perceived usefulness refer separately to a specific type or interface of a device (e.g. mobile phones, smartphones, PDAs) or, whether these judgments refer to a whole class of devices (e.g. mobile devices in general).
(2) *Task specificity*. Moreover, a broader range of experimental tasks should be examined in future studies. In the present study, we only included tasks from the digital diary of a PDA. Even though these tasks are highly prototypic features in mobile devices (Arning & Ziefle, 2006), one might object that these tasks do not have a major significance for all users or working contexts. Hence, it would be insightful to examine relevant tasks types that are important in professional work contexts (e.g. patient data management during the ward round in a hospital). At first sight, the perceived usefulness of a device might be higher, when the device is used for professional reasons and represents an essential and necessary part of the job or alleviates working procedures. However, as the evaluation of usefulness was associated with the ease of use in our study, we assume that even professional users, which rely on these technical devices, will report a lower ease of use – and as a consequence a lower usefulness – when the interaction with the system is hampered by usability problems. However, further research activities are necessary in order to examine if the perceived usefulness of devices differs in private and professional contexts.

6.2. The target group of older adults

The results confirmed that age plays a mayor role in the interaction with technology. However, two critical remarks should be considered in this context. The first is, that the examined sample of older adults is not representative for the population of the older age group. The older participants examined here were comparably young and had a quite high educational level, therefore future studies should examine older, and more representative samples. This is of special interest as older adults might particularly benefit from the utilization of mobile technologies (e.g. mobile devices serving as a memory aid).

6.3. The moderating role of individual variables

Even though a broad set of individual variables was included in the present study, there are more user characteristics to consider, which might also have a moderating effect on the relationship between technical performance and acceptance. Particularly the assessment of cognitive abilities (e.g. spatial and reasoning abilities, processing speed and memory abilities) might contribute valuable information to the explanation of technology acceptance and performance. Research has shown that cognitive abilities are strong predictors of age-related declines in performance, subjective technical confidence and the perceived ease of use (e.g. Arning & Ziefle, submitted; Ziefle & Bay, 2006). Apart from cognitive resources, emotional factors like computer anxiety or fear of failure and their interaction with gender or expertise should also be considered in future research.

6.4. Methodology

A final remark refers to limitations with respect to the applied methodology. Our results are based on the menu navigation performance in PDA software applications, using a simulated device. Moreover, participants worked with the mouse, an input device they were highly familiar with. This experimental setting was chosen in order not to overload participants (especially the older group) by too high workload demands, which are characteristic for the interaction with mobile devices in real environments. In a mobile context users have to manage different and complex demands simultaneously. They have to hold the device with one hand and the input device with the other, find their way through the PDA menu and search for a targeted function, meanwhile further attentional resources are required for activities in the mobile context (e.g. watching for traffic while handling the device). Moreover, in real environments visibility concerns have to be considered, as the visibility and legibility deteriorates in bright surroundings. In the end, it should be kept in mind that the results reported here are based on the interaction with the PDA in a controlled experimental setting. Therefore our findings must be considered as a solid underestimation compared to the demands given in a mobile context.

Acknowledgements

The authors thank Dominique Ziegelmayer, Lutz Böhnstedt, André Calero Valdez and Mahir Kilic, who programmed the computer emulation of the PDA device and Elisabeth Duetschke for research support.

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