Which Factors Form Older Adults' Acceptance of Mobile Information and Communication Technologies?

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Abstract. Technology acceptance has become a key concept for the successful rollout of technical devices. Though the concept is intensively studied for nearly 20 years now, still, many open questions remain. This especially applies to technology acceptance of older users, which are known to be very sensitive to suboptimal interfaces and show considerable reservations towards the usage of new technology. This study investigates long- und short-term effects on technology acceptance for a personal digital assistant (PDA) in older users. We examined the influence of users' personal factors (computer expertise, technical self-confidence) on acceptance (long-term effects). To assess short-term effects on acceptance, PDA acceptance was measured, after participants were given a PDA tutor training and interacted with a simulated PDA. According to the findings, individual factors largely determine people's acceptance showing that acceptance is mainly influenced by the individuals' learning history with technology. Though, also the tutorial training significantly affected acceptance outcomes, especially in the older group.

Keywords: Technology Acceptance, Perceived Ease of Use, Perceived Usefulness, Age, Computer expertise, Subjective Technical Confidence, Tutorial.

1 Introduction

In contrast to former times, in which the functionality of a technical system as well as aspects of technical feasibility were the main drivers of technical developments, the usability and the need of user-centered interface designs advanced to a key criterion of technological developments in the last decade [e.g., 1, 2, 3, 4, 5, 6]. In several studies published in different research areas (ergonomics, computer science, psychology, economics) it had been convincingly shown that the full benefit of technology decisively depends on usability and ease of use while interacting with technical devices [e.g., 7, 8, 9, 10, 11]. The concentration on the needs and wants of end users is highly opportune facing current societal developments. One development is the profound demographic change with an increasingly aging population. According to population-statistical forecasts, the proportion of people older than 65 years is assumed to rise from 25% to 56% [12]. Another trend is the continuously increasing proliferation of information and communication technology (ICT) in many parts of daily life [13]. Characteristically, the usage of ICT is not longer limited to professional areas. As

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opposed to the past, when mostly technology prone professionals were the typical end-users of technical products, nowadays broader user groups have access to information technology in various contexts [7, 8, 14, 15, 16] and its effective usage has become an essential requirement in today's working and private life. Apart from business applications, primarily mobile technologies are assumed to specifically support older adults in their daily lives. Referring to this, mobile devices are applicable in different fields, such as for instance medical monitoring, orientation aids, general memory aids or conventional personal data management. Although applications are supposed to be accessible to everyone, a gap between those, who are "computer-literate" and those who are not (predominantly older users) is emerging. Moreover, it should be kept in mind that older users – in comparison to those younger aged – in many cases considerably differ in their needs, abilities and competencies [17, 18, 19, 20, 21]. It is a central claim that these mobile devices are designed to correspond to older users' specificity and diversity [23, 24, 25, 26]. Therefore, mobile devices should be developed in a way that enables (older) people to use them and not only "for technologies sake" [14, 19]; and, what is even more important, that their appropriate quality and constitution tempt the consumer to accept and to use those devices. As long as mobile devices are not easy to use and learn, technical innovations will not have sustained success [19, 21, 27, 28, 29].

1.1 Usability of Technical Devices and Older Users

However, the mobile character of devices still represents higher usability demands. On the one hand, mobile devices are equipped with a specific display technology, which – from the visual ergonomic perspective – has negative effects on information access, especially for older adults [30, 31, 32, 33, 34]. On the other hand, mobile devices are often small-sized with a miniaturized communication window.

The limited screen space is extremely problematic for providing optimised information access. The small window space allows only a few items to be seen at a time, so that the complexity, extension and spatial structure of the menu are not transparent to the user while navigating through it. As a consequence, users are urged to memorize functions' names and their relative location within the menu. Disorientation in handheld devices' menus is a rather frequent problem [35, 36, 37, 38], especially for aged users or those with rather limited computer-related knowledge and experience [7, 16, 24, 26, 38].

In addition, the aging process further aggravates interaction with small screen devices for the older group. Age-related changes in the cognitive system lead to a decline in working-memory capacities, a slowing-down in processing speed and a reduced ability to distinguish relevant from irrelevant information [for an overview, see 17, 18]. As a result, older learners face greater difficulties in extracting relevant information from user manuals or they are overwhelmed with displays with a high information density. A reduced working memory capacity becomes critical when task demands are high, as for example when using novel or complex technical devices. Another profound decline over the life span concerns spatial abilities as well as spatial memory [11, 25, 36, 39, 40]. Older users with reduced spatial abilities experience disorientation and the feeling of "getting lost" while navigating through the menu of software. Thus, 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 [40, 41, 42]. However, the knowledge about the influence of age on the acceptance of a technical device and the correlation between usability and acceptance older adults is limited.

1.2 Acceptance of Technical Devices and Older Users

As the utilization of ICT is no longer voluntary and 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 ICT from our society. The majority of technology acceptance studies deal with the impact of ICT in the working context and address young and healthy adults as a major user group of information and communication technologies [43, 44, 45, 46, 47, 48]. Comprising the outcomes, it was found that the perceived ease of using a system and the usefulness are the key components of technology acceptance [43, 44, 45, 46, 47, 48, 49]. Recently, user characteristics (economic status, culture, gender, experience and the voluntariness of system usage) had been added to the original model to meet the requirements of understanding technology acceptance in a broader context [41, 46, 49].

It is reasonable to assume that the extent of technology acceptance depends on many more factors, especially in the older group. In this context, the learning history and the experience with technology might be a crucial factor. Technology acceptance – especially when encountering a new technical device – could be impacted by positive or negative experience with the own competence when using previous technical devices and the respective expertise with the usage of technology. It was found [50] that prior experience was associated with ease of use, but did not directly affect the behavioural intention to use the device.

The perceived usefulness of technology was identified to be lower in older adults [19, 29], 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 barrier, which is much more pronounced in older than in younger adults. On the other hand, positive experience when handling a new device could completely change acceptance, irrespective of previous learning history, as it could happen – for instance – after older adults receive a suitable tutorial and experience learning success in the subsequent usage of a technical device. The positive effects of appropriate tutors on the performance of novices when using a PDA had been shown in several studies [51, 52, 53, 54, 55], however the studies did not consider yet these effects on acceptance of older novice users.

Concluding, we do not yet fully understand the acceptance patterns of older adults when they deal with new technical devices and how acceptance can be influenced. In this research we would like to contribute to the understanding by examining long-term and short-term effects on older users acceptance of a PDA.

1.3 Question Addressed, Research Model and Hypotheses

We assume that acceptance of PDA usage – operationalized as perceived ease of use (PEU) and perceived usefulness (PU) of the device – is on the one hand influenced by individual factors such as self-confidence when using technology (STC), computer expertise (CE) and age, but on the other hand by the success of interacting with the PDA, which is modulated by the support of a tutorial given prior to interacting with it. The individual factors are considered as long-term effects as they reflect the learning history with technology. In contrast, the influence of the tutorial on performance, and consequently, on acceptance outcomes, can be classified as short-term effects. Beyond the question which of these factors impact acceptance to what extent, we also seek to answer the question, if acceptance is more strongly influenced by long-term, or rather, by short-term effects. A schematic model is illustrated in Figure 1.

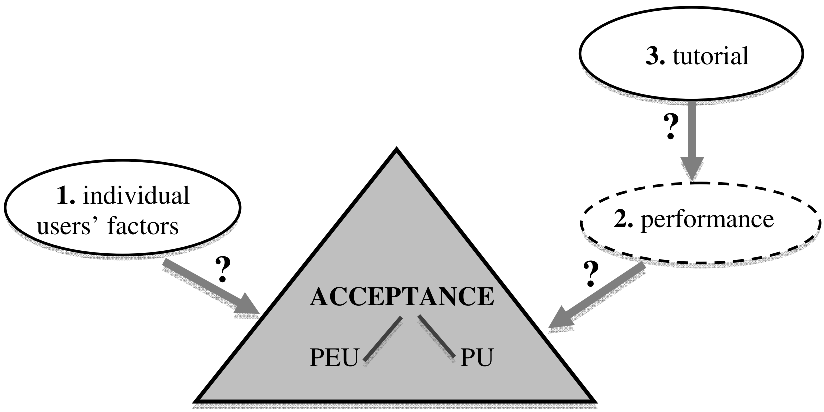

Fig. 1. Research model

According to the proposed model following hypotheses are specified:

H1: Individual factors such as age, computer expertise (CE) and subjective technical confidence (STC) are related to users' acceptance (perceived ease of use and perceived usefulness of PDA). Thereby, younger adults show higher computer-specific knowledge and a higher level of technical self-confidence than older users.
H2: Users with a higher level of CE perceive modern ICT-technologies as easier to use and more useful in comparison to those with lower level of CE.
H3: Users with a higher level of STC perceive modern ICT-technologies as easier to use and more useful in comparison to those with lower level of STC.
H4: Users' performance-effectiveness and -efficiency is related to the acceptance measures.
H5: Tutorial enhances performance on the PDA and affects indirectly users' acceptance. Thereby, older users benefit more from tutorial than younger users.
H6: Perceived ease of use (PEU) and perceived usefulness (PU) are positively related.

2 Research Method

The objective of the study was to revise which factors influence older users' acceptance of widespread mobile ICT-technologies. Based on a former research [7], which focussed exclusively on individual factors taking short-term determinants of acceptance into account, this study widens the acceptance research with an external component, which is an accompanying tutorial. Presumably, supporting novice (especially older) users with detailed instruction about how to realize applications in PDA could encourage their acceptance and therefore their usage of modern ICT-technologies. Since the current study claims to extend the earlier research, efforts were made to keep the method very similar to that used before. In this section the conceptual design and the procedure are described.

2.1 Experimental Variables

In our study we consider four independent and four dependent variables.

Independent Variables. Independent variables can be distinguished in long-term and short-term factors. Long-term variables represent user characteristics age, computer expertise and technical self-confidence, and they are classified as such, because they belong to users' specific learning history in the interaction with technical devices. Short-term effects are characterized as the moderating influence of a positive interaction with the technical device on acceptance.

Long-term factors: The first variable refers to users' age, contrasting younger participants aged between 20 and 29 years and older participants aged between 48 and 68 years. As a matter of fact the variable age acts as an indicator for two different technology generations dividing the sample in a group of users, which grew up with the modern technology, and in another group of users, who acquired their technical abilities over the years.

The second individual variable is directed to the level of computer expertise (CE) participants bring along. In order to find out, to which extent prior computer-specific knowledge would have an impact on acceptance outcomes participants were a priori distinguished in a group with high and a group with lower computer expertise. As older adults usually have lower prior computer knowledge – especially when compared to younger users – the median split procedure was accomplished age-related, forming two expertise groups within each age group according to their computer expertise scores. Thus, both, the older and younger group, held higher and lower computer-experienced subjects.

Additionally, participants' subjective technical confidence (STC), i.e. the degree of confidence to which a person believes in own ability to solve technical problems, was assessed. Similar to CE it was assumed that younger people would generally have a higher level of technical self-confidence in comparison to older users, so that the median splitting in groups of high and low technical self-confidence was conducted age-related as well.

Short-term factors: In order to examine short-term effects on performance, we applied a specific tutor training, which was found to be especially helpful in an earlier study [57]. One part of the sample received the tutor training prior to interacting with the device, while an another part – a control group – did not receive any tutorial help, but had to solve the specified PDA-tasks by their own. The tutorial was specifically developed for support of older adults and had been evaluated as effective in recent studies [55, 57]. Tutor format will be shortly explained in section 2.2.

Dependent Variables. As dependent variables two acceptance measures were surveyed: the perceived ease of use (PEU) and the perceived usefulness (PU) using original items of the Technology Acceptance Model (TAM, [43]; for detailed description see section 2.3). Those variables represented the core of this research and were observed for every manipulation of the independent variables. Additionally, two measurements concerning users' performance (effectiveness, i.e. the number of tasks successfully solved tasks, and efficiency, i.e. the time needed to process the tasks) were taken as the standard for usability [58]. These variables are assumed to reflect the (positive) tutor effect and, according to the specified hypotheses, mediate the tutor effect on acceptance.

2.2 Experimental Procedure

In order to test the research model and to determine the effects of long- and short-term variables on performance, an experimental setting with a simulated PDA was conducted. At the outset participants completed a computer-based questionnaire concerning demographical information (age, gender, educational achievement) and information about the familiarity with common technical devices (usage-length and -frequency of mobile phone and PC, as well as the perceived ease of using them). The fill-out was carried out by using the computer mouse and by choosing adequate answers from the prepared answer-lists. The same method was used later while task solving in PDA-simulation, and guaranteed that all attendees were experienced with the handling of the computer mouse.

Likewise computer-assisted, subjects proceeded a survey regarding technical self-confidence, where they had to tick the correct answers on a six-point scale (from 'strongly agree' to 'strongly disagree'). It was of great importance that STC-levels were assessed prior to using the PDA as the perceived tasks' success or failure could possibly bias STC-ratings. The preliminary data collection finished with a paper & pencil-test with regard to theoretical and practical aspects of computer knowledge and computer expertise, respectively [56].

With a next step participants worked on the simulated PDA and had to manage six prototypic tasks of the electronic organizer. In order to reflect a realistically task context, common applications of the digital diary were chosen (office and data management): three tasks requested entering of given information (e.g., entering of a new contact), and in the other three tasks modifying existing data (e.g., postponing appointment).

All participants were PDA-novices. One part of the sample (n = 40; treatment group) was previously instructed by an audio-visual tutorial (a computerized Microsoft Power-Point® presentation), which showed every single step necessary for successful task solving. Those participants learned two crucial functions needed for smoothly task solution: first, how to input a new entry into the device (button 'new'), and second, how to change corresponding details of an already existing entry (button 'edit'). Another part of the sample (n = 20) – the control group – did not receive tutorial help, but was solely instructed about the character of the imminent tasks. A basic task-information was printed on hardcopy and was present placed always next to participants in all groups (tutor and control), in order to give all participants the possibility to have a look at these instructions during the experiment. For each task there was a time limit of 5 minutes.

After completion of experimental tasks participants were asked to rate perceived ease of use (PEU) and perceived usefulness (PU) of the PDA they were working with. The described experimental procedure is presented schematic in figure 2.

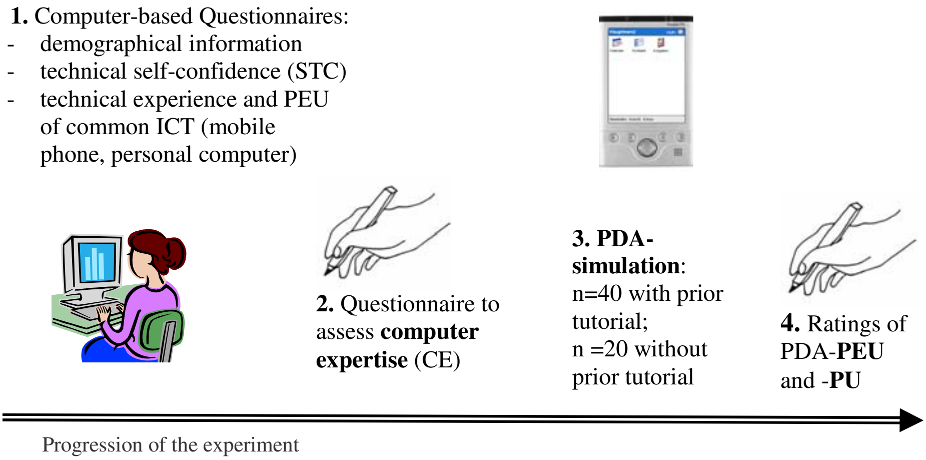

Fig. 2. Schematic schedule of experimental procedure

2.3 Materials

Perceived Ease of Use (PEU) and Perceived Usefulness (PU). Users' technology acceptance was assessed by original items from the Technology Acceptance Model [43]. The model integrates two main factors: firstly, the perceived ease of use (PEU) which implies 'the extent to which a person believes that using a particular system would be free of effort', and secondly, the perceived usefulness (PU) which is defined as 'the extent to which a person believes that using a particular system would enhance his or her job performance [43]. The validity and reliability of the items has been proven by several empirical studies [7, 9, 43, 44, 45, 47). Each of the 12 presented items (6 items for PEU, 6 items for PU) had to be approved or rejected on a five-point Likert-scale ranging from 1 (strongly disagree) to 5 (strongly agree). The maximum to be reached for each acceptance variable was 30 (max. TAM-value = 60 points).

Subjective Technical Confidence (STC). The technical self-confidence was measured by the STC-questionnaire [59]. It determines person's subjective confidence in his or her own ability to solve technical problems. The short version of the test containing eight items (e.g., "Usually, I successfully cope with technical problems", "I really enjoy cracking technical problems") had to be rated on a six-point scale from 1 (strongly disagree) to 6 (strongly agree). The maximum score was 40 points. According to Beier's own studies the reliability of the STC short version reaches satisfactory values (Cronbach´s alpha = 0.89). In the present study the reliability of the STC-Scale was even higher (Cronbach´s alpha = 0.91).

Computer Expertise (CE). In order to detect participants' level of computer expertise (CE), 18 questions about computer-related knowledge (i.e. theoretical and practical aspects of the computer structure) were placed. The questionnaire [56] had been specifically developed for the difficulty level of older adults (exemplary items are presented in figure 3). Reliability and validity reached satisfying values [56].

A 'search engine' is:

a) a specific robot for finding defined things autonomously ☐
b) a specific high performance computer for searching the internet ☐
c) a programme to retrieve data on the computer ☐
d) a databank to retrieve information in the internet ☐
e) 'I do not know' ¤ ☐

Your computer hangs up and you would like to restart it carefully. In order to do that

a) you press the 'reset' button ☐
b) you press the combination 'Ctrl + Alt + Del' ☐
c) you press the combination 'End + Enter' ¤ ☐
d) you turn off the computer and restart it ¤ ☐
e) 'I do not know' ¤ ☐

Fig. 3. Example-items for the computer expertise Questionnaire [56]

A multiple-choice format was chosen for answering the questions. Only one answer could be marked among four alternatives. An additional option "I do not know" was also given. Participants were not given a time limit filling out the questionnaire. The maximum score to be reached was 18.

Experimental Tasks. The experimental tasks referred to frequently used applications of a digital diary, which are standard software and a part of each PDA available on the commercial market. Overall, two task types, 'new entry'- and 'edit'-tasks, should be managed. For the 'new entry'-tasks between 16 and 30 clicks, and for the 'edit'-tasks between 9 and 13 clicks has been necessary to solve the tasks on the shortest way possible. Thus, overall a minimum of 94 clicks needed to be done. In the following, examples of both task types are described:

- Example for 'new entry'-task: *'You just made an appointment at the coiffeur Salon on Monday, the 2nd March, from 9 am to 11am. Please, enter this appointment into your digital diary and activate a reminder'.*
- Example for 'edit'-task: *'Last week you made an appointment with your tax adviser on 18th April, from 9 am to 10 am at his office, Stauffenallee, 89. But he just called to ask you, if you could postpone the appointment to the proximate week, the 25th April, same time, same place. Please, change the details of this notice in your PDA'.*

2.4 Participants

A total of sixty adults participated. Thirty young adults (9 males, 21 females) with a mean age of 25.2 years (SD = 2.5; range: 20 – 29 years) and thirty older adults (14 males, 16 females) with a mean age of 60.2 years (SD = 5.6; range: 48 – 68 years) took part. The younger participants were mostly university students of different academic fields (psychology, social science, engineering, communication science). Older users were reached by advertisement in a local newspaper and through their social networks, and covered a broad range of professions and educational levels (e.g. administrative officers, secretaries, teachers, nurses, engineers, physicians). Regarding the recruitment of older participants a benchmark procedure was pursued: "younger and healthy seniors" were aimed. All older adults participating were active parts of the work force, mentally fit and not hampered by stronger age-related sensory and psychomotor limitations. All participants were PDA novices. In order to assure a proper input device usage, participants completed computer-based questionnaires using a computer mouse. There were no great difficulties observed in handling the mouse, confirming participants' reported experience with it.

The technical experience (i.e. usage of mobile phones and computer) disperses in the tested sample. Analyzing holding duration ("For how long have you been working with…") and usage frequency of those technologies ("How often do you work with…") by older and younger adults, we found meaningful differences. In the younger group all participants held mobile phones (MP) as well as personal computers (PC). The mean value for duration of mobile phone holding period was 5.5 years (SD = 1.6), and the holding period for personal computer was on average 6.8 years (SD = 2.5) in this group. The frequency of usage [rated on a four-point Likert-scale from 1 (= less then once per week) to 4 (= daily)] approaches for both technologies almost the maximum value (M_{MP} = 3.9, SD_{MP} = 0.5; M_{PC} = 3.9, SD_{PC} = 0.4) and implies younger users' daily usage of common ICT. In contrast, in the group of older users only 90% (n = 27) declared to hold a mobile phone since on average 4.9 years (SD = 2.5), and to use it 2-3 times per week (M = 3, SD = 1.1). Moreover, all of the older participants possessed a PC (M = 4, SD = 3.5), but 10% of them seemed not to use or only sporadically use it. For the frequency of PC-usage resulted the mean value of 2.6 (SD = 1.4), which suggests that older people use their PC on average less than 2-3 times per week. In table 1 the outcomes of T-test for mean differences in the both age groups are presented.

Table 1. T-test for age differences of technical experience and ease of use variables for mobile phone and personal computer

	T	Df	p
Duration for holding a mobile phone	1.1	43.4	> 0.05
Frequency of using a mobile phone	3.6	36.7	< 0.01
Perceived ease of using a mobile phone	-5.3	45.4	< 0.01
Duration for holding a personal computer	3.5	52.4	< 0.01
Frequency of using a personal computer	4.4	30.5	< 0.01
Perceived ease of using a personal computer	-4.1	34.8	< 0.01

Also, the perceived ease of use (PEU) of the investigated devices differed significantly in both age groups. Participants were asked to rate the ease of use for those technologies ("how easy to use is for you …") on a four-point scale (1 = very easy, 2 = quite easy, 3 = quite difficult, 4 = very difficult). Younger participants rated navigating mobile phone as (very) easy (M = 1.4, SD = 0.5) and handling personal computer as quite easy (M = 1.9, SD = 0.4). Older participants judged using the small-screen device still as quite easy (M = 2.3, SD = 0.7), but getting along with personal computer was rated on average as quite difficult (M = 2.8, SD = 0.8) in the older group. Those differences in perceiving using common ICT-devices as easy are statistically significant (Table 1) comparing both age groups.

As the analysis for technical experience shows younger people use currently ICT-technologies evidently more frequently and they perceive the usage of these devices as easier in comparison to older users.

3 Results

Results of this study were analyzed by bivariate correlations, multivariate and univariate analyses of variance (M)ANOVA with a level of significance set at 5%. Outcomes within the less restrictive significance level of 10% are referred as marginally significant. The significance of omnibus F-Tests in MANOVA-analyses was taken from Pillai values. Acceptance measures (perceived ease of use and usefulness) were analysed non-parametrically (*Mann-Whitney-U*-Test). In order to integrate the individual factors computer expertise (CE) and subjective technical confidence (STC) as independent variables into the statistical analysis, a median-split method was conducted, respectively. Median values were assessed for the both age groups separately, so that within the particular group the number of participants with parameter values below the group-median (low), and of those who reached values above the group-median (high) was about the same size.

The result section is designed as follows: first, we assess correlative relations and impact of individual factors (age, computer expertise and technical self-confidence) on users' acceptance; second, correlative relationships between performance (supported by tutorial) and PEU and PU are conducted; and third, the influence of tutorial treatment on performance and its effect on acceptance measures are presented.

3.1 Impact of Individual Factors on Acceptance

At first, the analysis of the individual factors on acceptance ease of use and usefulness are of interest. Strictly speaking, ratings should be analysed non-parametrically. However, as we were interested in the interacting effects between independent variables on acceptance, which only can be assessed by (multiple) analysis of variance procedures, we decided to analyse data by the way of MANOVA. In order to be sure that we do not "overestimate" the significance of outcomes, we checked that the main effects yield the same significances in both, parametric and non-parametric testing procedures.

Relationships between Individual Factors and Acceptance. To get a first insight into the data, correlations (Spearman rank analyses) between individual variables and acceptance measures were carried out (table 2). Computer expertise was significantly correlated to both acceptance indicators (PEU: $r = .61$, $p < 0.01$; PU: $r = .26$, $p < 0.05$): with increasing computer expertise, the perceived ease of use and usefulness of the PDA is rated as higher. Moreover, the factors age and subjective technical confidence were significantly connected to the perceived ease of using the device (age: $r = -.50$, $p < 0.01$; STC: $r = .44$, $p < 0.01$), but not to the usefulness. Thus, with increasing age and decreasing technical self-confidence, the ease of using the device was rated as lower.

Table 2. Bivariate correlations between computer expertise, technical self-confidence, age and PEU, PU ($N = 60$). Bold values are significant (* p<0.05; ** p<0.01).

	PEU	PU	Age	Computer expertise	Subjective technical confidence
PEU	1	**.32***	**-.50****	**.61****	**.44****
PU		1	-.13	**.26***	.04
Age			1	**-.59****	**-.43****
Computer expertise				1	**.49****
Subjective technical confidence					1

Now, being aware of these relationships we inspect effects of individual factors on PEU and PU in the next step.

Effects of Age and Computer Expertise on Acceptance. A multiple analysis of variance with the between-factors age and computer expertise on dependent variables PEU and PU revealed highly significant effects of age (F (2,55) = 10.6, $p < 0.01$) and expertise (F (2,55) = 8.8, $p < 0.01$). The interacting effect between these factors though was not statistically relevant (F (2,55) < 1; n.s.). Descriptive analysis shows that the perceived ease of PDA-using was rated higher in the younger adult group (M = 24.4 points; SD = 5.1) in contrast to older users' ratings, which resulted considerably lower with 17.9 (SD = 6.1) out of maximum 30 points (F (1,56) = 21.6, $p < 0.01$). Age, however, did not significantly affect the perceived usefulness (F (1,56) < 1; n.s.): younger users rated the PDA just marginally as more useful (M = 20.2, SD = 5) than older users (M = 18.8, SD = 6.6). The effect of age on acceptance is presented in figure 4 on the left.

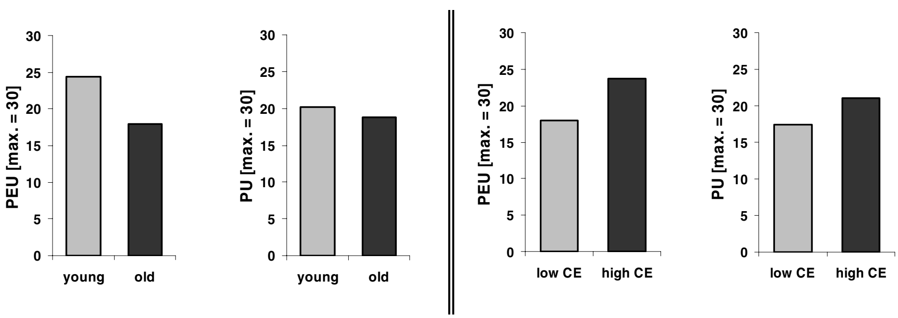

Fig. 4. Effects of age (left) and computer expertise (right) on PEU and PU (N=60)

Moreover, computer expertise revealed to be a major factor on acceptance (figure 4, on the right). Persons with high computer expertise rated the PDA as easier to use than those with lower level of theoretical and practical computer knowledge (F (1,56) = 15.3, $p < 0.01$), and they also judged usefulness of the device as higher (F (1,56) = 5.5, $p < 0.05$). Though, it should be noted that the average ratings for ease of use and usefulness (see table 3) are far from maximum values (20 out of 30 points), showing a basically reluctant acceptance.

Table 3. Means (and SD) for PEU and PU depending on level of computer expertise (*N* = 60)

Level of computer expertise	PEU	PU
Low	18.0 (6.5)	17.5 (6.1)
High	23.7 (5.2)	21.1 (5.2)

Effect of Subjective Technical Confidence on Acceptance. In addiction to computer-related knowledge also technical self-confidence affects users' acceptance judgments. In a MANOVA with factors age and the median-split STC on the dependent measures PEU and PU technical self-confidence showed a marginally significant impact on acceptance (F (2,55) = 2.9, p = 0.06). Persons, which are convinced about own technical abilities (scores above median), perceived ease of PDA-usage as higher than those, who showed rather lower technical self-confidence (scores below median). Interestingly, the latter tend to judge usefulness of the digital organizer even higher than high technically self-confident participants in the sample (for details see table 4). No interacting effect between age and STC (F (2,55) < 1; n.s.) was present.

Table 4. Means (and SD) for PEU and PU depending on level of STC (*N* = 60)

Level of technical self-confidence	PEU	PU
Low	19.9 (6.7)	20.2 (6.4)
High	22.5 (6.0)	18.6 (5.1)

Summarizing the results so far, we can assume that especially age and computer expertise, but also – to a lesser extent – the technical self-confidence affect users' acceptance of the PDA.

3.2 Navigational Performance Supported by Tutor and Its Impact on Acceptance

In this section firstly bivariate correlations of the experimental variables were carried out in order to find relevant relationships between acceptance and supportive as well as individual variables. With the next step the effect of prior applied tutorial on performance and acceptance measures is assessed.

Table 5. Bivariate correlations between PEU, PU and performance (N = 60; **p < 0.01, *p < 0.05)

	PEU	PU	No. of tasks solved	Time on task
PEU	1	**.28***	**.72****	**-.68****
PU		1	.23	-.25
Number of tasks solved			1	**-.71****
Time on task				1

Relationships between Performance and Acceptance Measures. Correlation findings for the whole sample (N = 60) – as can be seen in table 5 – show that the perceived ease of use is strongly related to performance effectiveness (i.e., number of tasks solved: $r = .72$, $p < 0.01$) and efficiency (i.e., time needed to solve the tasks: $r = -.68$, $p < 0.01$).

Outcomes suggest that users, who solved the experimental tasks faster and more successfully, perceive the PDA as easier to use in comparison to those who performed less effective and less efficiently. Perceived usefulness, in contrast, was not associated with the observed performance parameters (n.s.). These findings partially confirm prior formulated assumption (H4): performance is significantly linked only to PEU; it does not apply to PU. Furthermore, the indicators PEU and PU are related to each other, though not very strong ($r = .28$, $p < 0.05$), confirming H6.

In order to determine if the correlative relationships are equally strong in both age groups, we also execute correlation-analysis separately for the older and the younger users. Moreover, correlative analyses were also carried out separately for the treatment and the control group in order to get more information about the tutor effect (Table 6).

As can be seen in the upper part of table 6, younger users' perceived ease of use is not significantly associated with performance effectiveness (n.s.) but with efficiency in the tutored group ($r = -.62$, $p < 0.01$), indicating that shorter processing time in solving experimental tasks was strongly related to participants' positive opinions about the ease of PDA-use. In the younger group, which was not supported by tutorial (control group), neither effectiveness nor efficiency showed significant coefficients.

Table 6. Bivariate correlations between PEU, PU and performance variables (supported vs. not supported by tutorial) for younger and older users (**p < 0.01, *p < 0.05)

		PEU	PU	No. of tasks solved		Time on task	
				tutor	no tutor	tutor	no tutor
younger users (n=30)	PEU	1	.23	.28	.53	-.62**	-.08
	PU		1	.19	-.31	-.18	-.34
	Number of tasks solved			1	1	-.59**	.28
	Time on task					1	1
older users (n=30)	PEU	1	.35	.62**	.52	-.33	-.69*
	PU		1	.13	-.66*	-.12	-.30
	Number of tasks solved			1	1	-.29	-.40
	Time on task					1	1

For the older group (lower part of table 5) we found that persons, who previously received tutorial, rated the ease of use significantly higher the more effective their performance was ($r = .62$, $p < 0.01$); however, the tutor effect was not observed in task efficiency (time on task). In contrast, not tutored users perceived the PDA as more useful the shorter was their processing time ($r = -.69$, $p < 0.05$). In addition, in the older group a significant negative association between effectiveness and perceived usefulness was revealed (r = -.66, $p < 0.05$) for those adults, who did not receive tutorial, i.e. the higher the number of solved tasks the lower the PU-appreciation.

Effect of Applied Tutorial on Acceptance and Performance. As addressed before, H5 declares an effect of applied tutorial on performance and acceptance. A MANOVA with the factors age (younger vs. older users) and prior tutoring (tutor vs. no tutor) as independent variables, as well performance measures (i.e. effectiveness and efficiency) and acceptance measures (i.e. PEU and PU) as dependent variables was carried out. The outcomes revealed – beyond the effect of age (F (4,53) = 17.5, $p < 0.01$) – a highly significant positive effect of tutor on performance (F (4,53) = 3.9; $p < 0.01$).

At first we take a look on the performance (figure 5, right): participants previously instructed by the computerized tutor solved on an average more tasks (M = 2.6, SD = 2.4) than in the control group (M = 2, SD = 2). Similar pattern is obtained for the processing time (in seconds): the tutored group needed less time (M = 943, SD = 383.1) than the control-group (M = 947, SD = 352.7). Thus, participants who were supported by a tutor, worked more effectively and more efficiently than users without such training.

However, the focus of our interest was the effect of tutorial on the acceptance measures (figure 5, left). In the tutored group the perceived ease of use of the PDA was 22.7 (SD = 5.7) points and the perceived usefulness was 20.4 (SD = 6.2) out of maximum 30 points, each. In contrast, in the no-tutor-group the scores for acceptance measures were lower: here, users reached on an average 18 (SD = 6.9) points for perceived ease of use and 17.6 (SD = 4.6) points for perceived usefulness. Thus, users who were instructed by tutor before task solving pronounced considerably higher judgments about the perceived ease of use (single F(1,56) = 10.5, $p < 0.01$) and they also tended to perceive the electronic organizer as more useful (single F(1,56) = 2.9, $p < 0.1$) in comparison to those without prior treatment. Thus, the in H5 claimed influence of tutorial on performance and acceptance had been confirmed.

The interaction between the factors age and applied tutorial does not show a significant effect on the dependent variables (F (4,53) = 0.3; n.s.), which shows that the positive effect of the tutor on acceptance was for both age groups equally large.

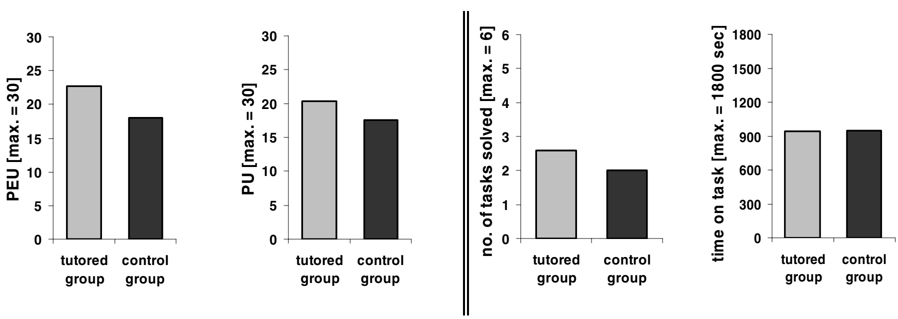

Fig. 5. Effects of tutor on acceptance (left) and performance (right)

Concluding the results in this section, tutorial has a positive effect on performance and, by this, on acceptance of mobile ITC-devices. Especially one aspect of novices' acceptance is strongly related to effectiveness and efficiency of performance: the perceived ease of use. This strong effect, however, fails to appear in regard to another indicator of acceptance, i.e. perceived usefulness.

4 Revision of the Research Model

We started this research with the basic question, to which extent older adults' acceptance of ICT-technologies is influenced by either long-term factors (individual characteristics) or short-term factors (tutor support and performance success). Based on the present research we now can a) furnish the assumed relationships with quantitative data and b) identify the key player on older adults' acceptance.

Long-term Effects. Among the user characteristics, computer expertise is the strongest driver of acceptance. People, who possess a high computer-related knowledge, show higher acceptance of ICT. This was to a lesser extent valid for the young adults (r = .32), but asymmetrically stronger for the older group (r = .54). The self-confidence when using technology turned out to be also a strong driver on performance (r = .44). People with a solid self-confidence in technical matters evaluate the ease of using the devices as significantly higher, but not the usefulness. Though, again, technical self-confidence impacted acceptance more strongly in the older group. The relationships furnished with data are illustrated in Figure 6.

Short-term Effects. Now we look at short-term effects and the question, if a successful performance – mediated by tutor support – comparably influences acceptance outcomes. Overall, high tasks success was positively correlated with acceptance (effectiveness: r = .68; efficiency: r = -.69). This hints at an important impact of a high usability and a positive experience of participants with the device interaction. If looking at the age groups separately, the tutor specifically supports the efficiency in the young group (r = -.62), while in the older group it supports in particular the effectiveness (r = .62). Apparently, the tutor is very supportive for both age groups, but the mode of operation is age-related. As the younger users already show a high tasks success, it is the efficiency, which is mainly advantaged. In the older group, which shows naturally a lower processing speed, it is the effectiveness, which is mostly supported.

Concluding we can say, that both, short-term and long-term effects do modulate acceptance outcomes. The success in performance with the device yielded a stronger effect on acceptance compared to the effects, which are carried by user characteristics. However, the positive tutor effect does mainly affect the perceived ease of use and does not impact perceived usefulness likewise. In addition, previous computer experience and expertise as well as – to a lesser extent – technical self-confidence modulate acceptance. It is insightful, that especially the previous computer experience and the familiarity with technology are strong predictors of acceptance in the older group.

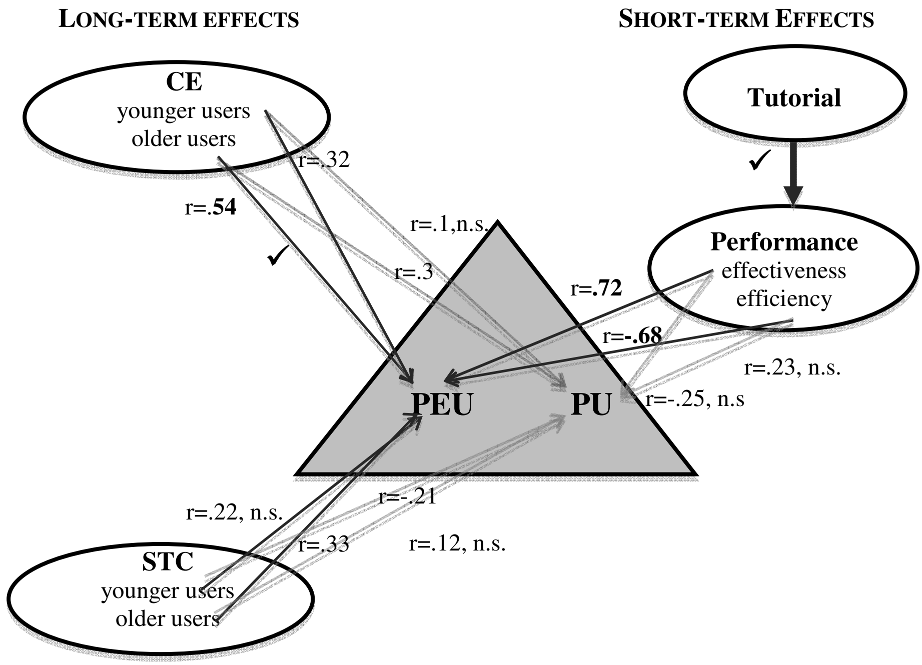

Fig. 6. Revision research model: influence of short- and long-term factors on acceptance (bold: $p < 0.01$). Black lines indicate significant impacts on PEU, grey lines represent insignificant impacts on PU.

5 Discussion and Future Research Duties

The present study was conducted to provide a deeper understanding of factors influencing user's acceptance of popular mobile information and communication technologies, taking a PDA and data management tasks as an example. Two key determinants of technology acceptance [43] were focussed in dependence of age, computer-related knowledge and technical self-confidence. The latter were assumed to be long-term effects. Also, the positive effect of a tutor was investigated, which should impact PDA performance, and by this, the acceptance of its usage (short-term effect).

In the focus of our interest were older users, as the demographic structure in the western world is continuously changing and it is supposable to expect that in the near future the majority of the population – and at the same time the majority of technology users – will be aged. In this regard, there is a need not only for meeting actual demands of the elderly and for appropriate adapting of technical products to this age group, but also, for understanding of basic necessities and customizing the technology market adequate to acceptance requirements.

The results revealed that among the long-term effects, predominately the previous experience and computer expertise were decisive for acceptance outcomes. While this was valid for younger and older users, confirming findings of other studies with mobile technologies [11, 25, 26], this was especially true for the older adults. This finding is very important regarding the impact of future educational efforts and life-long learning concepts. Only older adults' continuous motivation to actively handle technical devices, and to overcome the resentment and fear of failure towards technology may increase computer knowledge in this group on the long run. As has been exemplary found in an evaluative study in terms of computer expertise in older adults [56], an active exploration of technical systems provides those users with appropriate procedural and declarative knowledge components enhancing the perceived ease of using these devices. A successful device interaction on its part reduces computer anxiety and enhances computer-related self-efficacy [7, 8, 40, 41, 60, 61, 62]. However, the need for active participation in the interacting with new technology accepted and approved by older adults is only one side of the story.

The other side is the clear-cut importance of usability demands of technical systems, including the requirement of usable tutorial systems. The positive effect of the tutor on performance, and subsequently, on acceptance also showed that it is of great importance that users of ICT – especially the older ones – are adequately supported. As found, performance increase supported by the tutor enhanced the perceived ease of use, again especially pronounced in the older group. Facing that, any positive interaction with a technical device will shape and modulate the technical self-confidence and will reduce computer anxiety, the significant impact of a high usability of interface designs and age-sensitive tutors come to the fore.

People designing technical interfaces, electronic tutors and digital help systems need to take this sensitive relation between usability and acceptance serious. It should be kept in mind that any devices' technical genius and the promised advantage for users' daily needs can only be recognized and highly valued, if the human properties and cognitive specificities are properly recognized, and highly valued. Thus, whenever the knowledge of both the technical and the human factors are incorporated into current design, the devices may meet the demands of users, designers and manufacturers at the same time.

In the present study, short- and long-term effects could only be detected for one of the key components of technology acceptance [43], the perceived ease of using the PDA. In contrast, no effects on perceived usefulness could be identified, though the perceived ease of use and the perceived usefulness showed a basic correlation in the sample. The lack of the usefulness effect might be due to the specificity of the older group, corroborating earlier findings [19, 29, 34].

Melenhorst et al. [19] for example, explain the reluctance of older adults to weigh technological devices as "useful" by the lack of the perceived advantages, or the benefits. The perceived context-related benefit however is a major motivational factor for using or not using an electronic device. Older adults tend to be present-oriented and, consequently, do not see the need to evaluate technical devices as useful, which will be possibly used in future. The expected gain of the device may be perceived as not worth the trouble (learning cost, frustration and anger about a suboptimal usability [37]). This present-oriented attitude possibly reduces also older adults' preparedness to learn something new and to intensively deal with a new technology. Thus, for older adults, appropriate information about the benefits of technical devices represents an important determinant for using them. Provided the benefits are valued sufficiently high, they may overcome their reluctance and their susceptibility to effects of low usability and interface complexity. Taken this for granted, the usefulness represents the asymmetrically more important facet of technology acceptance for older adults compared to the perceived ease of using the device. Training the skills to handle a new technology should therefore involve information about its specific benefits, from the user's perspective.

On the other hand it is also very plausible that many of the present technical devices do not address a concise and coherent need of older adults beyond augmenting current entertainment and communication practices. In our study, participants did probably not apprehend the basic necessity to use additional device in order to execute day-to-day duties or storage information, and so they perceived the PDA as overall less useful. Future research should therefore include other kinds of device interactions and using contexts (e.g., medical technology), in which technology is basically welcome and needed by the older group.

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