Older adults' navigation performance when using small-screen devices: does tutor help?

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Nowadays ICT-technologies saturate the market and nearly everybody encounters them to a greater or lesser extent. This especially applies to mobile devices, which are increasingly used by diverse groups of end users. However, a bunch of mobile technical devices does not cater to older users and their demands. This paper reports the findings of a study that examined performance of older and younger adults using personal data management applications on a PDA in terms of effectiveness, efficiency, and acceptance.

INTRODUCTION

By now, the high technology standards of societies necessitate the interaction with a bunch of different technological devices. In the field of information and communication technology (small-screen devices, e.g. personal digital assistant) the market is rapidly growing constantly generating new products with increased functionalities. Moreover, the size of the conventional mobile ICT products is minimized all along tending to be small enough to be possibly taken wherever and whenever desired.

Due to the profound demographic changes within industrialized countries, especially seniors are becoming the main target group of modern technologies and will be addressed even more intensive in the future. This means that current small-screen devices will have to be adapted to this group of users all the more. However, creating and designing of innovative and easy-to-use technology for older people is challenging, out of several reasons. One is that aging process is associated with decreases in sensory, motor and cognitive abilities over the lifespan (e.g., Birren & Fisher, 1995; Czaja, 1997; Rogers & Fisk, 2000; Hawthorne, 2000), which to an unequal and individually varying extent influence the interaction with modern communication devices, depending on their progression in older adults. Findings from various studies that have been focused on older users' technology performance demonstrate fundamental differences in comparison to younger users: older adults generally need more time (Czaja & Sharit, 1993, Mead & Fisk, 1989, Freudenthal, 2001) and assistance to acquire computer skills (Charness & Bosmann, 1990, Echt et al., 1998), they commit more errors while working on tasks (Charness, Schumann & Boritz, 1992, Zandri & Charness, 1989, Arning & Ziefle, 2007) and solve less tasks successfully (Czaja et al., 1989, Mead et al. 2000, Ziefle & Bay, 2005). General cognitive slowdown with increasing age has been documented multiple times. One of the elementary cognitive mechanisms responsible for age-related differences in computer performance is perceptual speed, i.e. speed at which mental operations are executed (Processing-speed theory, Salthouse, 1996). The reduction in speed leads to impairments in cognitive functioning and has a significant impact on the performance efficiency (Park, 2000). However, the age-related performance differences are observable rather in novel than in well-known situations (Czaja, 1996).

Furthermore, the interaction between older users and technology products is overshadowed by barriers, which are based on lower cognitive skills on the one hand and emotional factors on the other hand, requiring a basic acceptance and an appropriate willingness to use them. Because older people especially are much more accustomed to manage their daily routine with paper and pencil, the usage of complex technical devices is often perceived as dispensable. Thus, people have to recognize the usefulness of the technical device before they use it. Generally, user satisfaction with a particular system is an important aspect of usability and it is determined by how easy or how pleasant the usage of system is. In fact, the success of existing mobile devices is highly dependent on the degree to which (older) people are willing to interact with them, and influenced by the extent to which the technical devices are accepted by this user-population (e.g., Arning & Ziefle, 2006).

In addition, older adults usually have a lower level of technical experience in comparison to younger users (e.g., Czaja & Sharit, 1993; Mead et al., 2000, Arning & Ziefle, 2008). This causes limited computer-related knowledge and vague concepts about how to handle (new) technical devices, which thereby disadvantages a successful device interaction and leads to negative emotions against technical innovations. Closely related to this is the phenomenon of rather slight technical self-confidence in older users. According to Beier (1991) technical self-confidence is a personality trait about the subjective perceived competence of the own ability to solve technical problems. This mechanism can bear on the performance in two ways: firstly, the technical self-confidence can affect the interaction with technical devices directly, when users feel technical competent or incompetent to solve technical problems, and secondly, it can indirectly impact the motivation to deal with technical devices and related technical problems at all.

Although the knowledge about older users' skills and attitudes, as well as their usage of ambient computing devices is still limited, the literature shows that older adults usually face larger difficulties than younger users in learning and using new applications (e.g., Kelly et al., 1995; Westermann, 1997). Unfortunately, the majority of new technical applications available on the commercial market – like small-screen devices – are mostly designed without considering special demands of older users. To bridge this gap, there is a need for ubiquitous solutions allowing users of different technology generations and ability levels a successful interaction with those technologies.

In order to facilitate access to technology and to enable an efficient customization process, the usage of tutors is recommended. However, according to statements of older computer users (e.g. Arning & Ziefle, 2006; Jakobs, Lehnen & Ziefle, 2008) tutors are often not perceived as helpful to the older consumer, because they do not respect the specific demands or they do not satisfactory fulfil the needs of older user. However, the usage of tutors is basically whished by the older users, who usually decline tedious trial and error behaviour when using technical devices, but they rather prefer a well-designed tutorial (Jakobs et al., 2008). Thus, we need to learn whether there are specific age-related abilities impeding a successful interaction with small-screen devices. We need to know what exactly older adults' difficulties are in the device interaction, and which of the older users' characteristics are responsible for these barriers. Not until we create a tutorial design, which takes user diversity and requirements into consideration, can we successfully assist and support user's navigation in technical devices.

The present experimental study focuses on the interaction of older users with personal data management software (of a *P*ersonal *D*igital *A*ssistant) after a prior computerized tutorial. The main question is if a given tutorial actually helps to improve orientation in the PDA menu and if it is beneficial to (older) users' navigation performance. In order to learn, which impact the given tutorial has on the navigational performance, we compared the performance of users *with* a tutorial to the performance of participants *without* a tutorial. The tutorial showed all actions needed for successful processing of the experimental tasks step by step and addressed both visual and auditory senses of the learner in order to facilitate the assimilation of the learn-materials. Additionally, the performance outcomes of older adults were compared to the results of younger adults in order to determine the age-specific effect of the tutorial. Moreover, to find out which particular user characteristics are involved proceeding common tasks in the digital diary (=PDA), we also surveyed users perceptual speed, users technical self-confidence and users experience with technical devices such as computer and mobile phone, and related them to the performance outcomes. Furthermore, user ratings concerning the usability of the investigated PDA were assessed.

METHOD

Participants

A total of 40 participants, 20 young adults between 20 and 29 years (M = 24.8, SD = 2.7) and 20 older adults between 50 and 68 years (M = 59.7, SD = 5.4) took part in this study. The younger subjects were recruited at the university and came from different academic fields (social sciences, psychology, engineering). The older adults were reached partially through newspaper advertisements and partially through the social network of older participants. A variety of professions were represented, e.g. teachers, engineers, administrative officers, nurses, architects, and physiotherapists. All participants were PDA-novices and they all received a small present for their participation. Ruling out further confounding variables, a careful screening of participants' abilities was undertaken. All participants were in good physical and mental health conditions. Visual acuity was normal or corrected to normal and no history of other visual or acoustic issues was reported.

Variables

There were two main independent variables examined in this study: (1) *user age*, contrasting the PDA-navigation performance of younger and older adults, and (2) *tutorial mode*, comparing participants' performance with and without prior computerized tutorial (tutor vs. no tutor).

Performance and acceptance measurements were used as dependent variables. As navigating performance, task *effectiveness* (number of correctly solved tasks and the percentage of correct accomplished steps) and task *efficiency* (time needed to complete the tasks and proportion of clicks per minute) were analyzed according to the standard for usability (EN ISO 9241-11, 1998). In our effectiveness analysis we took at first only the absolute results in tasks solving (number of successfully solved tasks). However, this binary analysis type (i.e. task solved vs. not solved) alone does not allow assessing satisfactory and rich in detail findings. Due to a specific logging tool, which was developed only for the experimental purposes, we were able to retrace every of participants' steps and observe, how far – in percentage – they came in the task solution. Hence, we additionally used this detailed, gradually effectiveness analysis (successfully accomplished steps) in order to detect any expedient effects.

Furthermore, users' technology acceptance was assessed by two summed-up factors: perceived *ease of use* (PEoU) and perceived *usefulness* (PU) of the simulated PDA according to the Technology Acceptance Model (Davis, 1989).

In addition, users' characteristics including technical self-confidence, technical experience and perceptual speed were assessed in order to learn crucial factors interacting with the navigation performance. *Technical self-confidence* was analyzed with the well-validated KUT-test by Beier (1999), which determines person's subjective confidence in his/her own ability to solve technical problems. It was of interest in this study, to inspect if, and how intense the belief in the own ability to manage (small-screen) technology affects navigational performance on the simulated PDA. *Technical experience* was measured by the summed up usage-frequency of common ambient technologies (computer and mobile phone). The question was, if frequent handling of other technical devices comes along with successful PDA-navigation in spite of the different menu structures (hierarchy vs. combination of network and hierarchy). Finally, in order to inspect participants' cognitive processing and its impact on the PDA navigation, *perceptual speed* was examined (Number Comparison Test from Kid of factor-referenced cognitive tests, Ekstrom et al., 1976).

The described variables regarding users' characteristics were split by medians into high and low ability or rather attitude group. The median splitting procedure was accomplished separately for both age groups respecting their different levels of the particular attribute.

Apparatus

From the perspective of ecological validity, to let participants work on a real PDA device would be the most natural experimental setting. However, as we intended to understand performance barriers on a detailed level, we needed to record participants' individual navigation routes. Technically, it was infeasible to record user's actions on the key-stroke level in the real device, therefore we used a computer simulation of the PDA, even though the work on a simulated device is much easier to accomplish.

The PDA (iToshiba Pocket PC e740, system software Windows CE, see Figure 1) was simulated as a software solution and run on a Dell Inspiron 8100 notebook PC that was connected to an LCD-screen (Iiyama TXA3841, TN, 15'', with a display resolution of 1024 x 768 pixels). The software emulation exactly corresponded to the real device, in size (chassis 80 x 125 mm), display size (3.5''), font size (9 pt for functions, and 11 pt (bold) for category headers), menu structure and operational keys.

For the experimental purposes a specific logging software tool was developed operating in the background while participants were working on the tasks. Due to this method a precise and non-intrusive measurement of the navigation behaviour was possible and allowed a detailed analysis of the effectiveness and efficiency parameters; for example: even when the tasks were not successfully solved in the designated time according to the binary type analysis (task solved vs. not solved), we were able to comprehend how far participants came in task solution (percentage of correctly accomplished steps).

Figure 1: Screenshot of the simulated Personal Digital Assistant

The presented tutorial was given on a Toshiba SM30 – 344 notebook PC (17", with a display resolution of 1280 x 800 pixels), which stood next to the participant being ready for use – if required – any time within the process of tasks solution.

Participants sat on a height-adjustable chair in a self-positioned comfortable seating position. In order to optimize viewing conditions, they were allowed to choose the distance and the angle of inclination to the TFT-monitor individually. If necessary, participants wore corrective lenses or glasses throughout the experimental time course. The participants completed the tasks with the computer mouse, as all of them were frequent computer users. In addition, assuring an unrestricted mouse usage, prior to task completion participants performed some practise trials with the computer mouse.

Design of the computerized tutorial

The main question of the experiment is whether the given (computerized) tutorial actually helps older users to an effective and effortless navigation using PDA and whether the tutorial affects users' navigation behaviour at all. In order to examine those effects two experimental groups were built: 1) a tutorial-group, which was provided with all information needed for a successful completion of the experimental tasks step by step, and 2) a control-group without a tutorial, that was simply informed about the kind of the forthcoming tasks and the time limit for its solution. The participants were randomly assigned to the particular groups, which consisted of ten younger and ten older adults, each. Due to this design we were not only able to show the differences between the groups with and without prior tutoring, but also to compare the performance of two supposed different technology generations within the focused (tutorial-) group.

The given tutorial was conducted immediately before solving the experimental tasks and addressed visual as well as auditory senses of the trainee. According to the Dual-coding theory of Paivio (1971) presenting information in this way provides for better contents memorizing. In a Microsoft Power Point presentation participants learned step by step two well-established daily functions of a digital diary: first, how to add a new entry into the device, and second, how to postpone an already existing entry or change some other details in it. This tutoring was proceeded without human intervention and the participants were informed to use the tutorial whenever they needed to. The idea was – similar to written instructions – to give a chance to hearken back to the learning contents in case of uncertainty of how to proceed next.

The tutorial described every step needed to solve new entry and edit tasks (examples are given bellow) and lasted about four minutes. The single steps were presented to the participant as screen-shots; e.g. new entry task: screen-shots of (1) how to open application 'digital diary', (2) how to find the button 'new entry', (3) how to enter different information about subject, location, date or time, and (4) how to save the entered details were successive shown on computer display, while a female voice simultaneously explicated those functions verbally using examples from everyday life. Analogically, the edit task was presented in single steps.

The instructing text was given in German, which was the native language of all participants.

Procedure and experimental tasks

All participants were tested individually. Before working on the experimental tasks they completed a computer-based questionnaire regarding demographic characteristics (e.g. age, gender), education and the familiarity with common electronic devices (personal computer and mobile phone). This method allowed familiarizing with the experimental setting and training with the computer mouse, whose handling was crucial for later exposure to the experimental tasks. Here, each question had to be filled out by choosing an adequate answer from a prepared answer-list. This procedure based on the same principle as the later tasks-solution and ensured user's sufficient ability to deal with the computer mouse.

After completing the questionnaire, all participants worked on the same tasks. One part of the sample (control-group, n = 20) was simply informed about the upcoming experimental procedure, i.e. the number of task they had to deal with and the time limit of 5 minutes per task. Another part of the sample (tutorial-group, n = 20) saw first the computerized tutorial – as described above – before starting the experimental tasks. Analogical, they were informed about the time limit per one single task. Immediately after the tutorial presentation, participants started to work with the tasks.

Overall, there were six tasks to solve, which were classified into two task-types. Three tasks referred to the creation of a new entry (adding of a new notice, new contact and new appointment), and the other three tasks required the editing of already existing entries (change address details, change contact data and postpone a date) in the digital diary. The tasks' order was held constant across all subjects and alternately arranged: it started with a new entry task, followed by an editing task, then a new entry task again, and so on. Examples of both task-types are given below:

- *'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' (new entry 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, the same time, the same place. No problem! Please, change the details of this notice in your PDA (edit task)*

The task information was written on a sheet of paper (task-items were presented in Arial Black, size 16, meeting possible legibility difficulties) and placed just next to the user.

After the tasks-solving users subjectively judged how "easy to use" and how "useful" they perceived the interaction with the PDA (based on Technology Acceptance Model, Davis et al., 1989).

RESULTS

Data resulted in this study were analyzed using bivariate correlations, multivariate analysis of variance and stepwise multivariate regression with a level of significance set at 5%. The significance of the omnibus F-Tests in the MANOVA analyses was taken from Pillai values. Acceptance measures (perceived ease of use and usefulness) were analyzed non-parametrically (Wilcoxon-W-Test for equal sample size and Mann-Whitney-U-Test for different sample size). In order to determine associations between performance outcomes and user characteristics, correlations were carried out (Pearson values were used for interval-scaled data, Spearman-Rho values for ordinal-scaled data). The result section is structured as follows: firstly, the correlations between relevant experimental variables are analyzed, and similarities as well as differences between younger and older PDA novice-users are presented. Secondly, effects of age and tutorial on performance and acceptance are described. Thirdly, the impact of user characteristics on users' performance and acceptance is pointed out. And fourthly, defining of the best predictor for a successful performance on the investigated PDA finishes the result section.

Correlative associations between experimental variables

At the beginning of our analysis we correlate the variables applied in this study in order to overview the experimental interrelations and to determine how they are associated. In addition, similarities and differences between the age groups are highlighted.

At first, age, tutorial and users' characteristics are correlated with performance parameters. As can be seen in the correlation matrix (Table 1), age is highly associated with all performance measures investigated in this study: totally effectiveness (TE: r = -0.65, p < 0.001), gradually effectiveness (GE: r = -0.71, p < 0.001) and efficiency measure (processing time (PT): r = 0.72, p < 0.001; clicks per minute (CM): r = -0.71, p < 0.001), which shows, that the higher the users' age the less tasks were solved correctly, the lower was the percentage of correct accomplished steps, the more time was needed to process the tasks, and the lower the number of clicks per minute which were executed while solving the task. For the variable tutorial no significant coefficients were revealed for the whole sample, but by checking the connections for both age groups separately, we detect strong associations with gradually effectiveness (r = 0.71, p < 0.001) and efficiency (clicks/min.: r = 0.54, p < 0.001) in the group of older users. Furthermore, the performance variables are also very strongly interrelated reaching coefficients between r = -0.75 and r = 0.9.

Table 1: Interrelations of the experimental variables (Spearman-Rho, N = 40)

			user characteristics			performance variables				acceptance	
	age	tutorial	PS	STC	TEX	TE	GE	PT	CM	PEoU	PU
age	-	,13	**-,52****	**-,46****	**-,48****	**-,65****	**-,71****	**,72****	**-,71****	**-,50****	**-,31***
tutorial		-	-,06	-,09	,24	,13	,22	-,05	,19	**,33***	,26
PS			-	**,43****	**,36***	**,65****	**,62****	**-,55****	**,63****	**,63****	,28
STC				-	,26	**,37***	**,45****	**-,69****	**,63****	**,51****	,17
TEX					-	**,59****	**,57****	**-,57****	**,63****	**,43****	**,57****
TE						-	**,90****	**-,72****	**,79****	**,72****	,30
GE							-	**-,75****	**,81****	**,75****	**,36***
PT								-	**-,87****	**-,66****	-,31
CM									-	**,71****	,29
PEoU										-	**,39***
PU											-

** p < 0.001, * p < 0.05

Now correlations with users' characteristics are reported. Users' age is negatively related to perceptual speed (r = -0.52, p<0.001) as well to technical self-confidence (STC: r = -0.46, p<0.001) and technical experience (TEX: r = -0.48, p < 0.001). Thus, with increasing age the level of cognitive processing (i.e. perceptual speed = PS) declines, and the subjective confidence in the own ability to solve a technical problem diminishes too. Also, the older the participants were the more decrease in the experience with technical devices is found. Further on, the described users' characteristics are not significantly associated with the variable tutorial, but taking the whole sample into account (N = 40) they are strongly linked up to the performance measures reaching correlation coefficients up to r = -0.7 (for detailed values see table 1). Within the single age group levels differences in the connections are apparent: in the younger group (n = 20) perceptual speed correlates significantly with the totally effectiveness (r = 0.48, p < 0.05), and technical self-confidence with efficiency (clicks/min.: r = 0.5, p < 0.05). Thus, higher perceptual speed is connected with a higher number of correctly solved tasks, and a positive belief in the own technical competence increases the efficiency of PDA navigation performance in this group. In the older sample ($n = 20$) perceptual speed is positively associated with the gradually effectiveness ($r = 0.51$, $p < 0.05$) and the efficiency parameter 'clicks/min.' ($r = 0.67$, $p \leq 0.001$), technical self-confidence is related to efficiency (time on task: $r = -0.74$, $p < 0.001$; clicks/min.: $r = 0.58$, $p < 0.05$), and the technical experience plays a considerable role in older users with regard to effectiveness of performance (totally: $r = 0.57$, $p < 0.05$; gradually: $r = 0.5$, $p < 0.05$).

At last, the connections of acceptance measures to the other experimental variables are described. Overall, perceived ease of use (PEoU) was negatively correlated with age ($r = -0.5$, $p < 0.001$), meaning that the higher the age, the lower the ratings for ease of PDA-use. But also the given tutorial is related to the subjective PEoU reaching moderately $r = 0.3$ ($p < 0.05$) and showing that people who received the tutorial, later positively rated the ease of PDA-use later on. Moreover, PEoU was highly related to the performance parameters (totally effectiveness: $r = 0.72$, $p < 0.001$; gradually effectiveness: $r = 0.75$, $p < 0.001$; processing time: $r = -0.66$, $p < 0.001$; clicks/min.: $r = 0.71$, $p < 0.001$) and is significantly associated with the users' characteristics (perceptual speed: $r = 0.63$, $p < 0.001$; technical self-confidence: $r = 0.51$, $p < 0.001$; technical experience: $r = 0.43$, $p < 0.001$). With regard to contents the findings indicate that PEoU was rated higher with higher perceptual speed, technical self-confidence and the experience with technical devices. In addition, people perceived the simulated PDA the easier to use, the more effectively and efficiently they solved the experimental tasks.

The other acceptance variable – perceived usefulness (PU) – was also negatively correlated with age ($r = -0.31$, $p < 0.05$), showing that the perceived usefulness is lower in the older group. Also, a strong interrelation of technical experience and perceived usefulness was revealed: the higher the users' technical experience, the higher resulted the judged PDA-usefulness ($r = 0.57$, $p < 0.001$). Overall, regarding performance, solely the percentage of successfully accomplished steps (gradually effectiveness: $r = 0.36$, $p < 0.05$) linked up to usefulness of the experimental device: people who reached higher scores in correctly accomplished steps rated – in general – the PDA also as more useful.

The correlations between acceptance measures differ in dependence of the age groups. While in the younger sample ($n = 20$) only performance effectiveness is moderately connected with perceived ease of PDA-use ($r = 0.4$, $p < 0.05$), in the older group ($n = 20$) there are associations with a given tutorial ($r = 0.5$, $p < 0.05$), with performance measures (up to $r = 0.74$), and with characteristics like perceptual speed ($r = 0.61$, $p < 0.05$) and technical self-confidence ($r = 0.56$, $p < 0.05$). Moreover, not in the younger but in the older group we observe positive coefficients between the perceived usefulness of PDA and performance (up to $r = 0.57$), perceptual speed ($r = 0.44$, $p < 0.05$) and technical experience ($r = 0.51$, $p < 0.05$).

Summing up the results, there are frequent and close meshed correlative connections between the observed experimental variables. Because users' age is strongly involved in the investigated processes, differences between younger and older users were presented. In the following we will analyze the effects of the independent variables on navigation performance and on acceptance measures.

Effects of age and tutorial on performance and acceptance

Now we take a look at the performance outcomes. In a multivariate analysis of variance performance of younger and older PDA-novices was compared showing a significant omnibus effect of age ($F(4,33) = 29.6$, $p \leq 0.001$). On the single F-tests levels the age effect was found for all effectiveness (binary analysis: $F(1,36) = 53.3$, $p \leq 0.001$; gradually analysis: $F(1,36) = 79$, $p \leq 0.001$) and efficiency measures (time on tasks: $F(1,36) = 54.5$, $p \leq 0.001$; clicks/minute: $F(1,36) = 93.2$, $p \leq 0.001$). The effect of age on performance measure is presented in Figure 2.

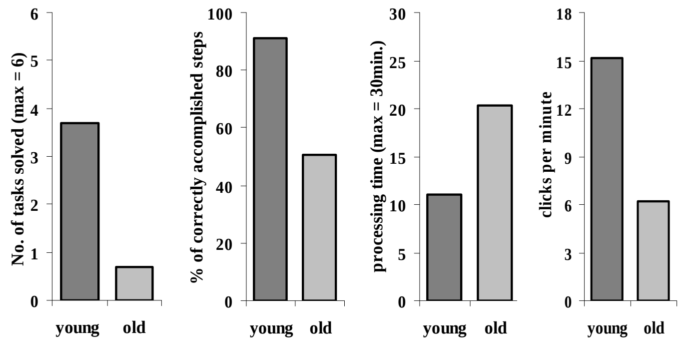

Figure 2: Effect of age on performance

Younger participants outperformed the older users significantly. They solved on average 3.7 ($SD = 1.5$) out of six tasks and accomplished 91.3% steps successfully ($SD = 10.2\%$) in just one third of the limited time ($M = 11$ of a total of 30 minutes; $SD = 2.3$). By comparison, older participants averaged merely 0.7 tasks successfully ($SD = 1$) and achieved 50.7% ($SD = 23.4\%$) of the maximum performance when looking on the detailed (= gradually) effectiveness analysis. They also needed nearly twice as much proceeding time ($M = 20.3$; $SD = 4.9$ minutes) and clicked on average less than half as frequent per minute as their younger colleagues ($M_{old} = 6.2$, $SD = 2.8$; $M_{young} = 15.2$, $SD = 3.4$), being at the same time less efficient.

Regarding effect of tutorial we found a significant omnibus value of $F(4,33) = 5.9$ ($p \leq 0.001$) indicating that those participants, who had tutorial support prior to completing the PDA tasks, proceeded them clearly more effectively and efficiently than test persons without such a guidance. On the single F-test level especially the gradually effectiveness analysis ($F(1,36) = 12.1$; $p \leq 0.001$) and the efficiency measure 'clicks per minute' ($F(1,36) = 7$; $p = 0.012$) proved that the tutorial-group had considerably benefited for solving the experimental tasks compared with the control-group. Describing the performance in detail, in the group taught by the computerized tutor the percentage of correct accomplished steps was significantly higher ($M = 79\%$, $SD = 20\%$) than in the uninstructed group ($M = 63\%$, $SD = 31.4\%$). Also, the average number of clicks per minute, indicating performance efficiency, varied significantly in both groups ($M_{tutor} = 11.9$, $SD = 5.6$; $M_{no\ tutor} = 9.4$, $SD = 5.2$) showing a frequency advantage for prior tutored users. The effect of tutoring on performance measures is demonstrated in

Figure 3.

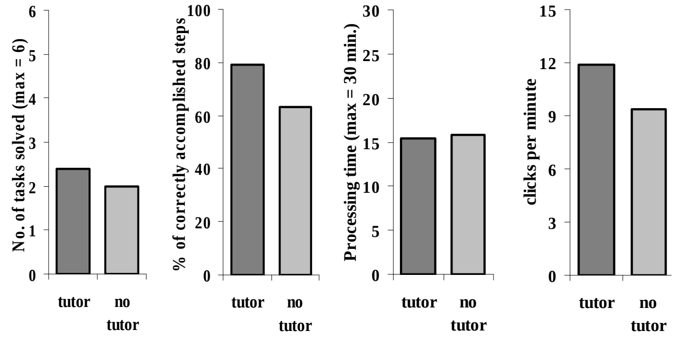

Figure 3: Effect of tutorial on performance

Moreover, there was a prominent interacting effect of both factors – age and tutorial ($F(4,33) = 5$, $p \leq 0.05$) approving mutual influence on navigation performance of our PDA-novices. The gradually effectiveness analysis ($F(1,36) = 11.1$, $p \leq 0.05$) enables us to illustrate the differences between the groups. While the effectiveness of younger users' only marginally differs in the both tutorial conditions ($M_{tutor} = 91.6$ %, SD = 12.3; $M_{no\ tutor} = 90.9$%, SD = 8.3), the performance of older participants instructed by computer tutor is almost twice as good ($M_{tutor} = 66.2$ %, SD = 18.4) in comparison to older adults without tutorial help ($M_{no\ tutor} = 35.1$ %, SD = 16.6). The measure of clicks per minute (n.s.) revealed as similar pattern showing that older persons with prior tutorial show a more purposeful and quicker task processing ($M_{tutor} = 7.7$, SD = 2.9 clicks/minute), than those without tutorial help ($M_{no\ tutor} = 4.7$, SD =1.8 clicks/minute). The interacting effect of age x tutoring on performance measures is illustrated in Figure 4.

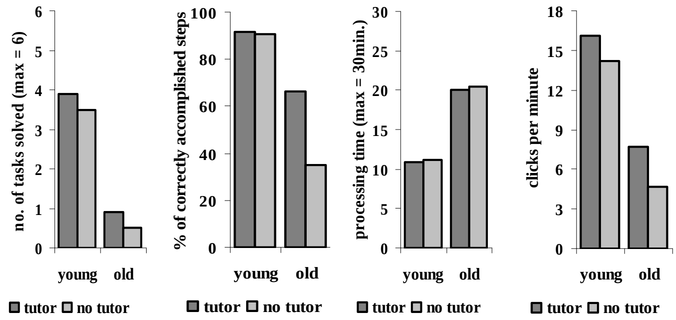

Figure 4: Interaction effect of age x tutorial on performance

Now, the effects regarding acceptance measures are described. At first, in order to gain insight into users' acceptance level we performed a nonparametric analysis of the two different age groups. Regarding the perceived ease of PDA-use ($Z = -3.4$, $p \leq 0.001$) the younger participants judged the usage of the device with 23.8 (SD = 4.8) points clearly easier than older test persons with 17.2 (SD = 6.5) out of 30 points. Unlike the ratings for perceived usefulness of the PDA, which differed not significantly between both age groups ($Z = -1.6$, n.s.). Younger as well as older participants judged the digital diary as quite useful, scoring with 17.5 (older) and 20.3 (young) out of 30 points in the upper half of the scale.

Also, the results for acceptance were analyzed comparing the group with and without tutor assistance. Results show significant differences in the perception of ease of use ($Z = -2.1$, $p < 0.05$). In the tutorial group participants judged the ease of using the digital diary at the level of 23 out of the maximum of 30 points (SD = 5.2). In contrast, the group without tutor assistance reached averaged 18 points (SD = 6.9). Apparently the given tutorial positively affects user's view of using the digital device. Regarding the measure perceived usefulness, there were – again – no differences found ($Z = -1.6$, n.s.) in the groups with and without tutoring respectively.

Effects of user characteristics on performance and acceptance

In a next step we inspect the impact of user's characteristics on performance effectiveness and efficiency as well on the acceptance measures. We first refer to performance outcomes encountered in this regard.

In a multivariate analysis of variance with the factors technical self-confidence, perceptual speed and technical experience we found a main effect of technical experience ($F(4,29) = 4.8$, $p \leq 0.05$; see Figure 5). On the level of the single F-Tests all effectiveness (totally: $F(1,32) = 4$, $p = 0.054$; gradually: $F(1,32) = 13.3$, $p \leq 0.001$) and efficiency measures (proceeding time: $F(1,32) = 6.2$, $p \leq 0.05$; clicks/min.: $F(1,32) = 8$, $p \leq 0.05$) reached statistically significance.

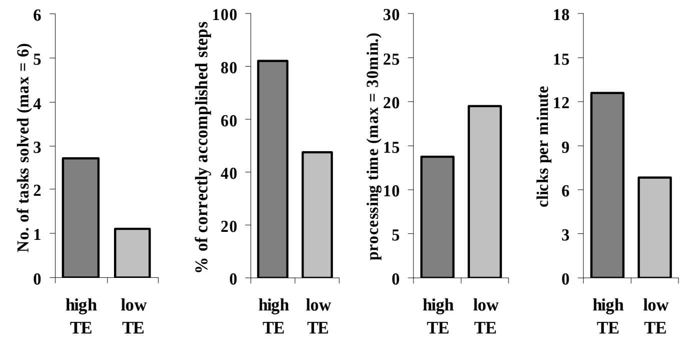

Figure 5: Effect of technical experience (TE) on performance

Participants with a high level of technical experience, i.e. those who daily use technical devices like computers and mobile phones, clearly outperform subjects with infrequent usage of electronic devices. High technically experienced participants solved on average 2.7 (SD = 1.7) tasks and accomplished 82.2 (SD = 15.2) percent steps successfully in not even the half (time on tasks in minutes: M = 13.8; SD = 5.5) of the designated maximum of time (30 minutes). In contrast, the low technically experienced group solved on average 1.1 (SD = 2.1) task and accomplished 47.7% (SD = 31%) steps correctly in 19.5 minutes (SD = 5.4). Also, the efficiency measure 'clicks per minute' shows the advantage of technical experience: high experienced users clicked almost twice as much (M = 12.6; SD = 4.8) with the computer mouse as the low experienced users (M = 6.8; SD = 4.6). Even though the differences between expertise groups were expected and show the enormous benefit of technical experience on the navigation performance, it should be noted that even the experienced participants solved only about

50% of the tasks correctly. This shows that the interface design of small screen devices imposes considerable cognitive demands, even for quite "simple" data management tasks.

There were no main effects of perceptual speed (F(4,29) = 2.1, p > 0.1) and technical self-confidence (F(4,29) = 1.4, p > 0.1) on performance measures found in this study.

However, not only technical experience is a benefiting factor for PDA performance. As taken from the interacting effect of perceptual speed and technical experience (omnibus value: F(4,29) = 3.6, p ≤ 0.05; see Figure 6) also the extent of processing speed advantages PDA performance, partly compensating the detrimental effect of a low technical experience: technically inexperienced users with low level of perceptual speed solved on average solely 0.7 (SD = 1.9) tasks and needed 22.4 minutes (SD = 4.9) to process it, while those with a high level of perceptual speed solved more than twice as much experimental tasks in considerably shorter time (tasks solved: M = 1.7, SD = 2.4; processing time: M = 16.1, SD = 4 minutes).

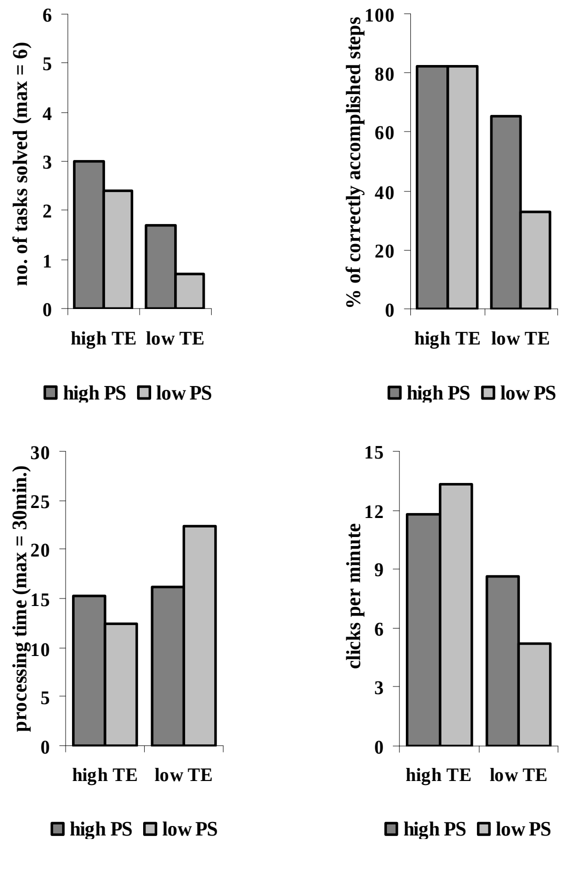

Figure 6: Interaction of technical experience (TE) and perceptual speed (PS) on performance measures

In the high technical experience group the differences are not that prominent, but still, those who have a high level of perceptual speed showed better performance than those ones with a lower performance speed level (high processing speed: M = 3, SD = 1.7; low processing speed: M = 2.4, SD = 1.7 correctly solved tasks).With reference to the effect of technical experience described above, we assume that the impact of frequent usage of technical devices and thereby gained practice is crucial for the performance and lets the novice-PDA-user navigate more effective.

Regarding acceptance measures, a significant effect of technical experience on the rated ease of PDA use (Z = -2.8, p ≤ 0.05) and perceived PDA usefulness (Z = -3,4, p ≤ 0.001) was found showing that participants with a higher technical experience rate the ease of use and the usefulness of the PDA device as higher.

For the attributes technical self-confidence and for perceptual speed there were no significant differences found for the high vs. low levels groups with respect to the focused acceptance measures.

Which user characteristics are most influential for navigation performance of novice PDA users?

We finally define the best predictor(s) for the navigation performance on PDA (effectiveness and efficiency measures) taking all presented independent variables in multiple stepwise regression analysis into consideration. First, we refer shortly to the outcomes of the whole group for the sake of completeness, but we predominantly concentrate on the results of the older users as they are in focus of interest in this paper.

Taking the whole experimental sample into account the variable users' age emerge as the best predictor for efficient and effective navigation explaining between 56 and 67 percent of the variance of the particular performance variables considered in this study. Other variables contributing to the variance-explanation in the particular effectiveness and efficiency measures are given below in the regression equations (in parentheses: percentage of the explained variance):

- Totally effectiveness (62%) = 6.3 + 0.9*perceptual speed – 3*age
- Gradually effectiveness (76%) = 97 + 6.5*tutorial + 14.5*perceptual speed + 11.9*technical self-confidence + 11.9*technical experience – 35.4*age
- Processing time (70%) = 3.9 + 9.1*age – 4*technical self-confidence
- Clicks per minute (78%) = 21.3 + 1.3*tutorial + 2.7* technical self-confidence – 8.8*age

Table 2: Results of multiple stepwise regression analysis (N = 40; VIF = Variance Inflation Factor < 5)

Dependent Variable	Predictor	Adj. R^2	ß	T	p	VIF	ANOVA
totally effectiveness	perceptual speed	62.1%	0.2	2.3	p=0.029	2.8	F (2,37)= 32.9, p ≤ 0.001
	age		-0.8	-7.9	p≤0.001		
gradually effectiveness	tutorial	76.3%	0.2	2.8	p=0.008	4.8	F (5,34)= 26.1, p ≤ 0.001
	perceptual speed		0.3	3.4	p=0.002		
	technical exper.		0.2	2.1	p=0.044		
	STC		0.2	2.8	p=0.009		
	age		-0.6	-7.2	p≤0.001		
time on task	STC	70%	-0.3	-3.7	p≤0.001	3.5	F (2,37)= 45.7, p ≤ 0.001
	age		0.7	8.6	p≤0.001		
clicks per min.	tutorial	77.9%	0.2	3.2	p=0.003	4.9	F (3,36)= 46.8, p ≤ 0.001
	STC		0.2	3.3	p=0.002		
	age		-0.8	-10.8	p≤0.001		

In the following we concentrate on the older group and analyse which of the variables under study might be the most decisive for the navigation performance. The regression analyses revealed the tutor condition as the most powerful predictor for the effectiveness (gradually: 44%) and efficiency (clicks per minute: 26%) of performance. Next, subjective technical self-confidence contributes to the explained variance, however, solely for efficiency measures (processing time: 31%; clicks per minute: 16%). Finally the variable perceptual speed also plays an important role for effectiveness of older novice-users navigating through the menu of the digital diary (gradually effectiveness: 20%). The regression equations presented bellow give the details for the explained variance in the group of the older participants (in parentheses: percentage of the explained variance):

- Gradually effectiveness (64%) = 24.6 + 15.6*tutorial + 21*perceptual speed
- Processing time (31%) = 22.8 – 5.7*technical self-confidence
- Clicks per minute (42%) = 3.8 + 1.4*tutorial + 2.4* technical self-confidence

The regression outcomes show that older adults PDA performance may be attributed to a number of variables. However, it is important to note that it is the tutor condition which is the most powerful predictor for performance, and not, as might have been expected, the specific cognitive characteristics of the older group. This outcome is encouraging, as it shows that there are basically promising ways to enable older adults to efficiently use digital devices overcoming their disadvantages by the decreasing age-related abilities. As the analysis shows, instructing older participants, how to execute some daily applications using the electronic device step by step is generally beneficial and supports effectiveness as well as efficiency of PDA-menu navigation. We assume that a continuing user-centred optimization of tutorials for small-screen devices might be a promising way to motivate older users to use these devices.

DISCUSSION AND CONCLUSION

The present study was conducted to provide a deeper understanding of PDA navigation performance in older users, and to learn crucial technical pitfalls and barriers when using these devices. In order to get an insight into age-related abilities accounting for performance decrements we studied also technical self-confidence, technical experience, and perceptual speed of participants. To determine the extent of the age-related performance decrements we compared the performance of the older group to that of a young technology-prone user group.

Another key aim of the present study was to evaluate the advantage of a computerized tutor. It was analysed if and how effective a computerized tutorial helps (older) users to navigate a novel technical device, which they had no prior experience with, while they dealt with common new entry and edit tasks of the digital diary. The tutor was carefully designed and contained a step-by-step procedure of the PDA tasks to be completed. Following Paivio's dual coding theory (1971), the information was presented visually as well as auditorily. Furthermore, users' opinions regarding PDA-usefulness and ease of PDA-use were surveyed and related to performance outcomes.

Clearly, it was found that user's age is a very influential factor for the menu navigation performance in small-screen devices. Throughout, older adults show a less successful and less efficient navigation performance compared to a young adult group. However, this finding is not surprising and confirms previous studies which reported similar effects for different technical devices (hypertext: e.g., Lin, 2001, Ziefle et al., 2007; computers: e.g., Czaja & Sharit, 1993; mobile phones: e.g., Ziefle & Bay, 2006). Also, merely determining age effects is not helpful on the long run as long as it is not analysed (1) which factors underlie the aging disadvantage and which should be addressed by technical design approaches, and (2) which key stones can be identified that my compensate the ageing disadvantage.

In this study, we assessed the effects of perceptual speed, self-confidence and technical experience when using technical devices. To begin with perceptual speed, no main effect of this cognitive factor could be revealed. Though its influence became noticeable in the interaction with user's technical experience proving that a higher level of it is beneficial for handling the investigated small-screen device. In contrast, the technical experience was found to be a key player for the navigation performance, especially in the older group (Ziefle, 2002; Arning & Ziefle, 2008). Participants with a higher level of technical experience, showed a higher tasks' success and a considerably more efficient processing. Thus, we can assume that using (and simultaneous practising with) common technical devices like personal computers or/and mobile phones facilitates distinctly the usage of novel handhelds, even when their menu structure is disparate. Analyzing the data it is obvious, that older adults encounter those technologies less frequently than younger users and they are disadvantaged regarding knowledge about basic concepts and related actions conventionally used in those technologies (e.g., closing the application by a cross in a little square). Finally, the importance of the technical self-confidence for navigation performance is looked at. One could have assumed that older adults report a significantly lower self-confidence when handling technical devices, and that the lower self-confidence is negatively affecting navigation performance. As found older adults' technical self-confidence is actually lower than that of younger adults (e.g. Arning & Ziefle, 2007). It is though noteworthy that the performance was not prominently affected (no main factor). However, gathering the information from correlation and regression analysis, successful PDA navigation is associated with a positive attitude towards technical matters and a high self-confidence, respectively. In the group of older participants, a higher level of technology-related self-confidence was especially connected with performance efficiency, i.e. shorter processing time and proportionally more mouse clicks per minute, hinting at a more purposeful navigation style.

Summing up the impact of age-related user characteristics, the findings show that both, cognitive abilities and affective components carry the age-related performance. The knowledge about user's characteristics contributes to a better understanding of ageing processes and their influence on technical device usage and is helpful for creating interface- as well as instructional design adapted to all recipients age-independent.

In this context tutorials are playing an important role enabling to compensate some cognitive shortcomings or technical incompetence. The present research was concerned with the question, if a given tutorial is beneficial to especially older users' navigation performance meeting novel mobile communication devices like the PDA. Looking over the findings, it becomes evident, that the applied tutorial clearly supports the performance in PDA usage. Users, who were instructed prior to the tasks processing managed them more effectively and more efficiently in comparison to participants, who were not previously told how to handle the experimental tasks. Moreover, the tutorial assistance was found to asymmetrically advantage older users showing that appropriate and well-designed tutors may compensate age-related performance decrements. The benefit of tutors was especially effective for less gifted older users (those who have a lower level of perceptual speed and technical experience): the negative effect of having a small technical experience and a low perceptual speed were partially evened out when the tutorial was applied. But still, the difference in the overall effectiveness of task solution between age groups is large: tutored older users solved, on average, only one out of six tasks. It should be noted that the tasks were quite conventional (data management tasks) and not difficult to understand. Also, 5 minutes per task were given – plenty of time compared to the real life conditions (in which not many users are assumed to patiently spend 5 minutes on one PDA task). Beyond the aging impact, these outcomes show that small-screen devices available on the market do not at all meet the abilities, needs and wants of the older user group, but need to be re-designed.

Even though the performance of the younger group was distinctly better (solving four out of the six tasks in considerably shorter time), the low usability of current interface design become evident once more. Considering that the younger adult group is technology-prone (high technical experience), bright (high cognitive functioning), assertive (high self-confidence when handling technical devices) and well-educated (students of a technical university), the outcomes give cause for serious concern, corroborating that current interface designs do not even match the cognitive abilities of the “best case”-user groups. The question emerging from this fact is why not even those users are able to perform the tasks with maximum of success. In addition, the usage of the digital diary in small-screen devices may also be hindered by a rather sparse and unspecific feedback, by usability problems with hard and soft keys, as well crucial discrepancies between user’s expectations and mental models on the one hand and the real design on the other (Wilkowska & Ziefle, submitted).

A careful support in form of tutorials is needed all the more, in order to facilitate the dealing with common software applications and to avoid user’s disorientation in the menu structure. Moreover, according to our findings regarding users’ acceptance, we found that PDA-acceptance after prior tutorial is higher in comparison to the control-group. Thus, implementing standard tutorials will presumably increase the general acceptance and also the usability of the electronic mobile handhelds. Older people are – more than expected – highly motivated to use new technologies (e.g., Ziefle et al., 2007), however, they show great difficulties when changing over to new operating routines and they are very sensitive to suboptimal interface design (e.g. Arning & Ziefle, 2007; Ziefle, Arning & Bay, 2006). As long as information designs of technical devices are not easy to use and to learn, technical innovations can not achieve sustained success and are accessible solely to a fractional amount of the technology population. Therefore, future studies should continue this line of research and examine different tutor formats in order to find an optimal supporting solution fitting all users, independent from age and level of technical experience.

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