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Age and computer self-efficacy in the use of digital technologies: an investigation of prototypes for public self-service terminals

Günther Schreder[1], Michael Smuc[1], Karin Siebenhandl[1], Eva Mayr[1],

[1] Zentrum für Kognition, Information und Management, Donau-Universität Krems, Dr.-Karl-Dorrek-Str. 30, 3500 Krems, Austria
{Guenther.Schreder, Michael.Smuc, Karin.Siebenhandl, Eva.Mayr}@donau-uni.ac.at

Abstract. Previous research suggests that self-efficacy (SE), i.e. the belief 'in one's capabilities to organize and execute the courses of action required to produce given attainments' (Bandura), plays an important role in the usage of self-service technologies especially for elder customers. Two experiments with different prototypes of ticket vending machines (TVM) were conducted. Participants were selected according to their age (half of the participants aged 55 or older) and levels of general computer self-efficacy (CSE). The first experiment shows that CSE contributes to both the user´s performance and ratings of task-specific SE, while age affects the performance only. The second experiment indicates that using the novel TVM increases the user's task-specific SE except for elder users with low CSE – who faced critical problems in the more complex tasks. Results indicate that future research on digital inclusion should focus on elder users with low CSE.

Keywords: ticket vending machine, self-service terminals, self-efficacy, age and technology, older adults

1 Introduction

The project INNOMAT[1] centers on how a new generation of self-service ticket vending machines (TVM) should be designed to best meet the needs of different user groups. Special needs and requirements of senior citizens, disabled persons and people lacking technological skills have been identified based on a literature review, and observations and interviews have been conducted at railway stations [1]. Results revealed a number of serious barriers to the use of the ticket machines, above all among older and middle-aged passengers. Specifically, users felt overwhelmed by the multiple options offered and the information they were asked to provide, and/or they

[1] The INNOMAT project was funded by the research programme „Ways2go", Austrian Federal Ministry of Transport, Innovation and Technology (BMVIT). Project consortium: Austrian Federal Railways (ÖBB Personenverkehr AG), Danube University Krems (Department for Knowledge and Communication Management), Create Mediadesign GmbH, PL.O.T. EDV-Planungs- und HandelsGesmbH and Allied Panels Entwicklungs- und ProduktionsGmbH.

did not succeed in selecting the proper options. It could be argued that the general changes in perception, motor skills, memory and cognition, as a consequence of aging [2], are accountable for these observations. However, some respondents expressed little confidence in their ability to buy a ticket at the machine successfully and reported being eager to avoid them altogether. They referred to bad experiences and distrust of the technology. While these problems were partly linked to technical problems and the rather complicated fare system (e.g., the relevant fare has to be entered before some products can be selected), these results indicate low self-efficacy in the context of using digital technologies. Similar results were found in Great Britain [3], [4] as well as Taiwan [5], where elderly use the ticket machines only seldom and believe less in their own abilities.

According to Bandura [6], self-efficacy (SE) is the belief "in one's capabilities to organize and execute the courses of action required to produce given attainments." People with a higher sense of SE will take greater efforts and show more persistence in accomplishing a task. At the same time, SE influences thought patterns and emotional reactions:

"*High self-efficacy helps create feelings of serenity in approaching difficult tasks and activities. Conversely, people with low self-efficacy may believe that things are tougher than they really are, a belief that fosters anxiety, stress, depression, and a narrow vision of how best to solve a problem. As a consequence, self-efficacy beliefs can powerfully influence the level of accomplishment that one ultimately achieves. This function of self-beliefs can also create the type of self-fulfilling prophecy in which one accomplishes what one believes one can accomplish. That is, the perseverance associated with high self-efficacy is likely to lead to increased performance, which, in turn, raises one's sense of efficacy and spirit, whereas the giving-in associated with low self-efficacy helps ensure the very failure that further lowers confidence and morale."* [7]

In the experiments of Czaja et al. [8], 'computer self-efficacy' (CSE) was an important predictor of the use of technical devices, while being influenced by computer anxiety was a mediator. For people with low self-efficacy, the probability of using the technology was generally reduced. Additionally, people with high computer anxiety reported less experience with computers and the Internet and reported using these technologies for a smaller number of different activities. The combination of both factors resulted in the active avoidance of technological devices. As low CSE is frequent with senior citizens, the authors stressed the importance of using technology that allows senior citizens to experience success so they are able to build up confidence in their abilities. Consequently, one of the aims in developing a new TVM was to ensure that people who are nervous of the ticket machines or are characterized by low CSE can feel that they can master the task easily and without the help of others. In four focus groups held at Danube University Krems, a range of ideas for the new TVM were developed and discussed by experts as well as specific target groups (i.e., senior citizens and people with little technological literacy). Several of the ideas collected included new ways of selecting a destination by entering the target station in a search bar on the start screen (similar to the Google search bar); an "intelligent" ticket machine, which recognizes regular customers and instantly provides a list of their most recent journeys; knows the passenger's current position and offers the best

deals to the most popular destinations from the current location. A detailed description of the User Centered Design Process can be found in [9].

Based on the outcome of the focus groups, design workshops were conducted, and three prototypes were programmed by the project partners. Each of these prototypes featured the selection of the destination, a choice of different types of passengers and the selection of the travel date and ticket class. One of the biggest challenges in designing them was the realization of a proper passenger configuration system that allows the selection of different types of passengers (e.g., adults, children, families, dogs) and possible travel cards for each of them in order to calculate special group fares and offers.

Prototype A - "Virtual Ticket": The first interface was a contemporary adaption of the current system. It consisted of an overview and featured typical elements of human-computer interaction, like sub-menus and drop-down menus (see Figure 1).

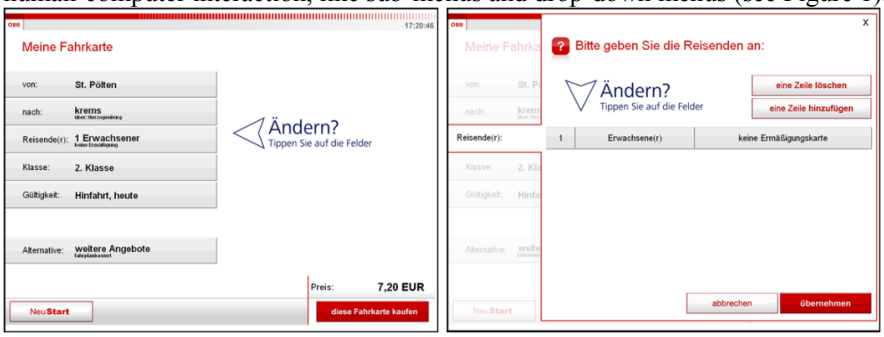

Fig. 1. Prototype A – overview (left) and passenger configuration (right).

Prototype B - "Netherlands Clone": This system was a modification of the easy-to-use system currently used in the Netherlands. All possible options can be seen immediately, and the user's current selection is highlighted. To account for the higher complexity of the Austrian fare system in comparison to the Netherlands, we developed a novel person configuration where graphical representations of passengers can be selected (see Figure 2).

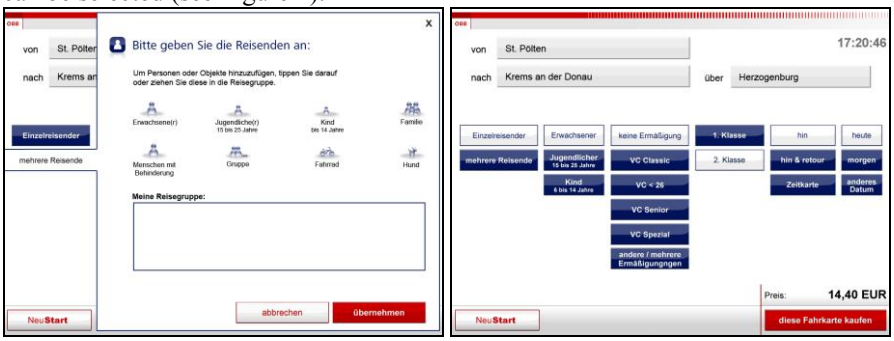

Fig. 2. Prototype B – Selection of passengers (left) and options screen (right).

Prototype C - "Train Metaphor": Although largely similar to prototype B, this option extended the graphical metaphor by using a train narrative and animations. The

selected passengers "move" into a train, and any options selected are visualized by train wagons moving into the correct position (see Figure 3). More detailed information on this prototype can be found in [11].

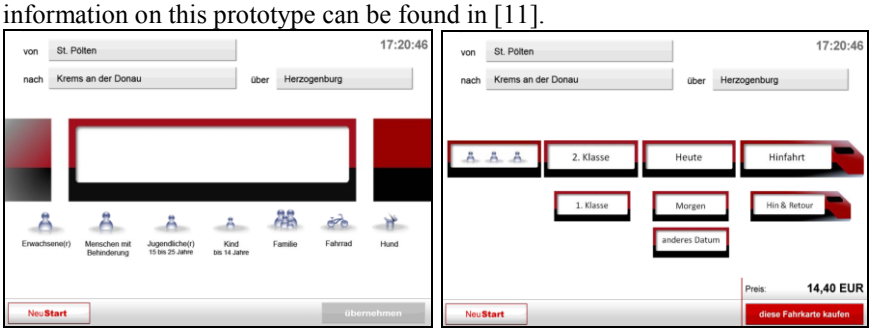

Fig. 3. Prototype C – passenger selection (left) and options screen (right).

Though a large plethora of different methods were actually used to gather data for the iterative development of the new TVM (see [9] for a detailed summary), the focus of this paper is the impact of age and computer self-efficacy on the usage of the novel prototypes. We hypothesize that though age has an important effect on the efficiency to use a TVM (e.g., time needed to solve a task), CSE will be at least as important. Second, the user´s confidence to actually buy a ticket successfully at a TVM will depend on their CSE rather than their age. Ideally, the new TVM should build up the user´s confidence to be able to successfully buy a ticket by providing positive experiences with it.

2 Experiments

In the course of the INNOMAT project, two experiments were conducted. Participants were recruited using the volunteers´ database of Danube University´s department for Knowledge and Communication Management. They were selected according to their age (half of them older than 55) and levels of computer self-efficacy. CSE was determined via the results of a computer self-efficacy questionnaire developed specifically for this project that was answered by the participants during the recruitment phase. Participants responded to 10 items in the form of "I am able to use a computer to find information on the Internet" or "I am able to write a letter in Word". For the experiments we chose only participants who scored within the lowest and highest third of the CSE range respectively.

2.1 Experiment 1

Method. In a 2 x 2 laboratory experiment, 48 participants with differing levels of CSE (determined via the results of a computer self-efficacy scale: 24 low, 24 high) and of different ages (24 participants over and 24 under the age of 55) interacted with the three prototypes (within-design, balanced order). The interfaces were presented to

the participants on a touch screen. For each prototype, the participants were given four tasks presented as fictitious travel stories: 1. a standard ticket for a single person, 2. a discount ticket for a family of two adults and one child, 3. a ticket for a single person for a return journey in the local transport network and 4. tickets for a group of three adults – including one travel card holder – for a return journey in the local transport network. While these use cases were all based on current ticket sales statistics, care was also taken to include rather complex purchase scenarios that would not have been possible on the current system. Emphasis was also placed on ensuring that the users would receive a choice of different types of offers to simulate the complex fare structure. The time and number of interactions needed to complete the tasks were recorded. To measure task-specific SE participants had to respond to several questions asked by the experimenters between the tasks: they had to estimate if they would be able to solve the next task correctly and if they feel confident that it would not take them a lot of time to accomplish it.

Results. Repeated measures ANOVA (dependent: time and clicks needed) indicated significant effects both for between-subjects factors [2 (age) x 2 (CSE)] and for within-subjects factors (prototypes). First, the amount of time (Figure 4) and number of clicks needed to complete the trials were higher for participants with low CSE ($F(2,44)=11.85$, $p<.001$, $\eta^2_p=.35$) and older participants ($F(2,44)=7.96$, $p<.01$, $\eta^2_p=.27$) with no significant interaction. Second, the participants needed less time as well as fewer interactions to complete the tasks with prototype C than with the other prototypes ($F(4,42)=3.79$, $p<.05$, $\eta^2_p=.27$).

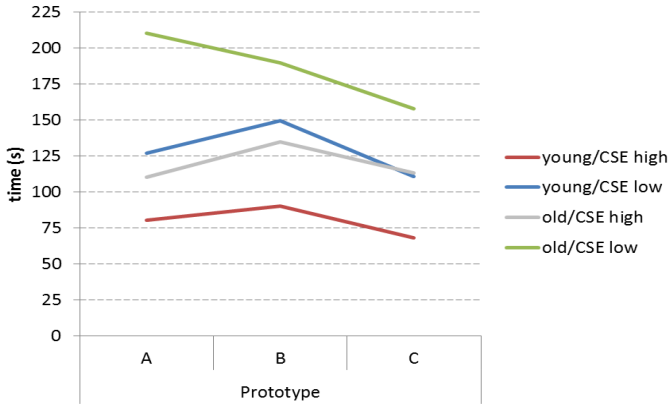

Fig. 4. Accumulated times (in s) to accomplish the tasks for each prototype.

The repeated measures ANOVA of the SE-scale shows very similar results. Participants are generally more confident in using prototype C ($F(2,46)=7.62$, $p<.01$, $\eta^2_p=.25$) and when their CSE is high ($F(1)=6.75$, $p<.05$, $\eta^2_p=.13$). However, age is not a factor contributing to the SE estimations of the participants (Figure 5).

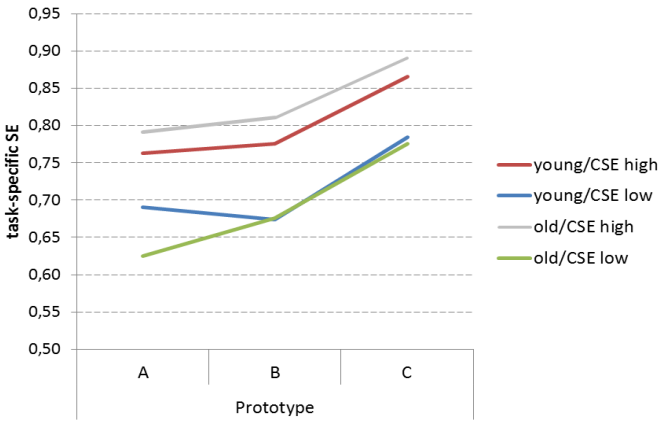

Fig. 5. Means of task-specific SE for each prototype

While CSE contributes to both the user´s performance and ratings of task-specific SE, age affects the performance only. The results indicate that prototype C ("Train Metaphor") induces a higher sense of confidence in one´s capability to acquire a valid ticket than the other prototypes. Even users with a generally low level of computer self-efficacy seem to benefit from this system. By applying an everyday graphical metaphor (selecting passengers by moving them into a train), users were guided through the purchase process.

These findings led to the decision to develop this interface further and drop the other two prototypes. Nonetheless, some aspects still needed further refinement or were incomplete (e.g., the automatic display of a choice of low cost options for the selected parameters or a personalization system that allowed users to select their most frequent routes). The look and feel of the prototype was also revised to better reflect Austrian Rail´s corporate identity and branding (see Figure 6). The complete purchase process of the refined software consisted of five steps: 1. start screen with the selection of the destination, 2. selection of passengers, 3. travel options, 4. selection of fare and special offers, 5. payment.

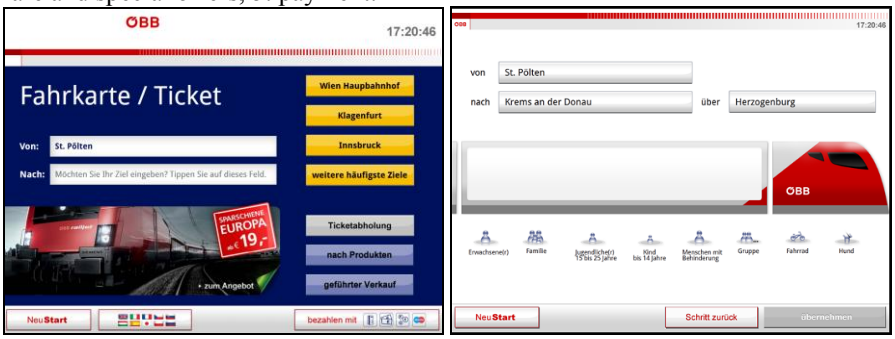

Fig. 5. New start screen (left) and passenger selection (right).

2.2 Experiment 2

Method. Similar to experiment 1 described above, a 2 x 2 laboratory experiment (within-design, balanced order) was conducted with 48 participants with differing levels of computer SE according to the results of a computer SE scale (24 low, 24 high) and of different ages (24 participants over and 24 under the age of 55). The participants were given the same four fictitious travel stories used in experiment 1, but, this time, they interacted with the TVM prototype built by the project consortium (Figure 6). The same measurements as used in experiment 1 were taken (i.e., time needed to solve the tasks and number of user interactions). Since computer self-efficacy is dependent on the subjective feeling of having made progress during training [12], the participants were asked to rate their confidence of being able to successfully buy a valid ticket before and after the trials. The task-specific self-efficacy questionnaire used was created specifically for this experiment and was based on the approach described by Bandura [13]. The TVM-SE questionnaire began with "Please rate how certain you are that you can buy one of the following tickets successfully at a TVM" and comprised of 13 items, like "train ticket at normal price," "a ticket for 2 persons and their bicycles," "the cheapest ticket for myself, when other customers are queued behind me." The scale ranged from 0 ("Cannot do at all") to 10 ("Highly certain can do").

Fig.6. Hardware prototype.

Results. The analysis of time measurements points at the critical elements of the purchase process. The participants needed the most time to select the passengers (Figure 7). In a 2 (age) x 2 (CSE) repeated measures ANOVA, we found that younger participants ($F(1)=12.77$, $p<.01$, $\eta^2_p =.24$) as well as participants with higher CSE scores ($F(1)=10.02$, $p<.01$, $\eta^2_p =.20$) were generally quicker in solving the tasks (no interaction).

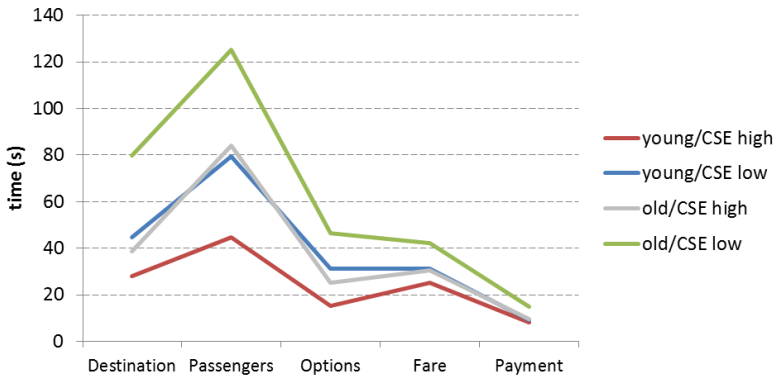

Fig. 7. Average time needed (in s) to complete the five steps of the purchase process.

Focusing closely on the passenger selection, the results of a 2 (age) x 2 (CSE) repeated measures (4 tasks) ANOVA shows that the participants´ difficulties with the more complex tasks (Figure 8). While it took all of the participants longer to complete task 2 in comparison to task 1 ($F(1,49)=10.37$, $p<.01$, $\eta^2_p=.18$), older participants with little CSE needed far more time to complete task 2 than the other participants ($F(3)=6.39$, $p<.01$, $\eta^2_p=.28$).

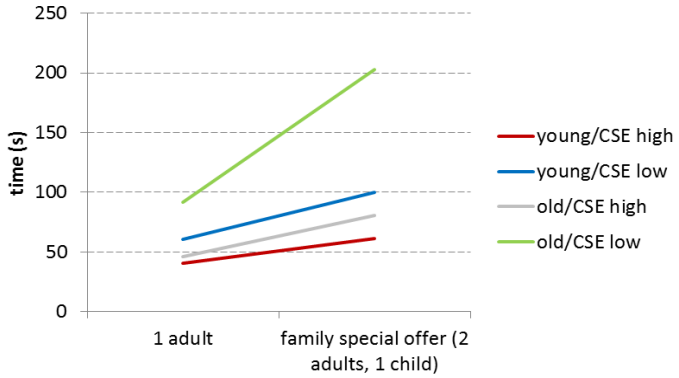

Fig. 8. Average time (in s) needed to complete the passenger selection during task 1 and 2.

The 2 (age) x 2 (CSE) repeated measures (before/after the trial) ANOVA revealed that the starting values for the TVM-specific self-efficacy scale[2] (measured before the test) were significantly higher for participants with high CSE than for those with low CSE ($F(1)=9.17$, $p<.01$, $\eta^2_p=.28$). Yet these values also increased significantly after the participants had used the ticket vending machine ($F(1, 49)=29.41$, $p<.001$, $\eta^2_p=.38$). The only exception here was the group of elderly people with low CSE (significant interaction: time of measurement*age*CSE, $F(1,49)=4.70$, $p<.05$, $\eta^2_p=.09$), who did not experience a significant increase to their TVM-SE (Figure 9).

[2] Cronbach´s alpha was rather high (.97), indicating a fair amount of redundancy. Nevertheless, all items were summed to calculate the TVM-specific SE score.

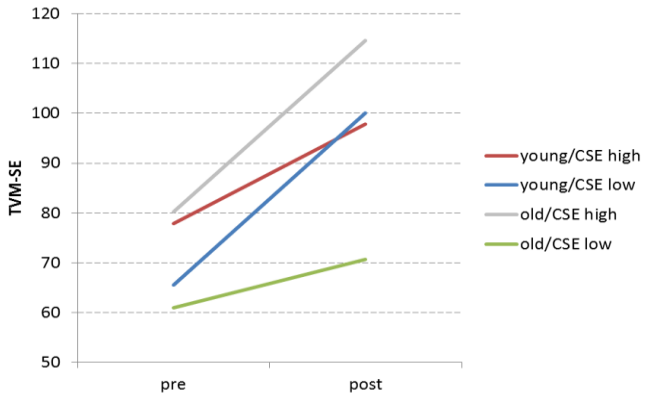

Fig. 9. Means of TVM-SE measurements before and after the trials.

3 Conclusion and Discussion

As a high sense of SE accounts for resilience in stressful situations [7] and influences the motivation to use a technological device [8], SE seems to be an important factor for the success of public self-service systems. Thus, the development of a novel TVM that positively influences the customer´s feeling to actually be capable to buy a valid ticket was one of the major aims of the INNOMAT project.

Though a low SE in technological domains is more often associated with the elderly, it has to be emphasized that there are also younger people with low CSE. The newly developed TVM could be seen as a success at least for this user group, which adapted quickly to the system and showed large increases in their TVM-SE when using it. Still, some improvements to the graphical passenger selection are needed if the system will be implemented in the future, as elder participants with low CSE encountered more difficulties during this step, which accounted for their unchanged TVM-SE after exposure to the TVM.

Some aspects must be considered: Self-efficacy, beyond actual ability, significantly leads to overestimation of the ability to complete tasks [7]. It should not be the aim to develop a system that "hides" its complexities and conveys a false sense of simplicity to the users. We selected very complex tasks for the experiments, and participants sometimes forgot to select a travel card or chose the wrong type of passenger. Especially the elder participants wanted to see the instructions again during the difficult tasks and had problems keeping them in mind. Possibly the tasks were too difficult or seemed artificial for some of the participants. Subsequent research might include field studies to account for these problems, as participants would rather work on self-chosen tasks than fictional ones created to work in a controlled laboratory environment. One advantage of this approach would be that especially members of the described target group that seemed to profit least from the prototype could be observed while solving tasks that match their personal needs. Ultimately, if the new TVM would provide the possibility to fulfill those needs, it

could be seen as successful, regardless of chances to theoretically solve more complex tasks. Enhancing the users´ SE may be a critical asset of a public self-service terminal, but only when people actually use it or envision its usage. Additional strategies must be developed for customers who shy away from the TVMs, like demonstrations, learning platforms, and trainings. However, if public technologies can be designed to facilitate mastery and users gain a feeling of success, self-efficacy can be increased in the long run and might also reduce the perceived barriers to using other kinds of media.

In summary, this is the first study to demonstrate the impact of CSE and age on the use of public self-service terminals. While the results of the experiments were consistent with our hypothesis of an approximately equal importance of age and self-efficacy, we were not able to devise an approach that might be helpful for elder users with low CSE. Further research on the inclusion of elderly in the digital society could benefit from a differentiated approach based on the incorporation of additional factors such as self-efficacy.

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