Young by Design: Supporting Older Adults' Mobility and Home Technology Use through Universal Design and Instruction

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Abstract. The dominance of computer technology in work and leisure poses particular challenges for older people. Specifically, their lack of computer literacy impedes their ability to explore and use new interactive systems. To investigate the effect of computer literacy and two approaches to compensate a lack thereof, 62 older (M=68 years) and 62 younger (M=25 years) participants were split evenly into three groups: the video group watched a brief instructional video immediately prior to solving eleven tasks using a simulated ticket vending machine, while the control group did not and the wizard group used a redesigned wizard interface instead of the original simulated ticket vending machine to solve the same eleven tasks. Results indicate that both age groups benefited from watching the video, while older adults benefited more, so much so, that they were as effective as the younger non-video group. For the wizard condition age differences were practically eliminated. Particularly efficacy and satisfaction of the older group increased substantially. This result suggests that the careful design and integration of minimal instructions or wizards into interactive devices could contribute to maintain independent living and societal integration for older people.

Keywords: Human-computer interaction, universal design, computer literacy, video instruction, ticket vending machine, design for all, interaction knowledge.

1 Introduction

Mobility and independent living at home are two essential contributions to life satisfaction in old age; Considering age differences in technology use performance and the potential benefits of technology use, it seems fair to say that careless design might incapacitate people regardless of age and make them feel “older” than they are and that careful “universal” design might contribute to make older people effectively “young by design”.

This paper presents an overview of two research projects investigating such a “universal design” approach in the context of Information and Communication Technology (ICT): The first, called ALISA, exemplifies this approach with the use of a ticket vending machine and has been completed, the second (SMILEY), aims to apply this approach in the context of Ambient Assisted Living (AAL) and is work in progress.

C. Stephanidis (Ed.): Universal Access in HCI, Part III, HCII 2011, LNCS 6767, pp. 230–239, 2011.

Technology could support older adults in their desire to maintain a self-sustained lifestyle, for it can extend our range of possible actions [1] and delay cognitive decline by providing „cognitive enrichment” [2]. However, older people are often reluctant to use modern computer technologies: In their lifetime, they have had less opportunity to use them and gather the necessary interaction knowledge and the knowledge they have acquired becomes obsolete quickly as technology develops faster and faster. Hence, it is important to acknowledge that the very design of technological artifacts can contribute to a growing digital divide as well as reduce it, e.g. by following a “universal design” approach.

2 Method

Following such an approach, the ALISA research project used a ticket vending machine (TVM) to investigate in a 2x3 factorial experiment (age (young/old) x experimental condition (original TVM/video/wizard), which user characteristics best explained age differences in successful TVM-interaction (“computer literacy” was the best predictor) and whether age differences could be mitigated by a brief video-instruction and by a user interface redesign (Wizard).

2.1 Participants

Participants were recruited in two age groups; The older comprised of a total of n=62 adults (M=68.2 years, SD=4.8, 35 female, 27 male) and the younger of n=62 younger adults (M=24.5 years, SD=4.14, 29 female, 33 male). Both age groups were well educated, with a slight advantage for the younger group (old/young: 21/11 College (Fach-/Hochschule), 5/34 Highschool (Abitur), 12/17 Intermediate Secondary School (Realschule), 19/0 Secondary General School (Hauptschule)). The older group consisted mainly of pensioners (51), while people in the younger group were mostly students (34) or working (18). Most participants used the TVM once a month or less (old: 23/ young: 46) or never (old: 35/ young: 6). The majority (71%) of the older group avoided the use of TVMs, while most of the younger group (74%) did not.

Instruments and procedureThe age groups were split evenly into three experimental conditions. The video condition differed from the control condition only in one aspect: participants watched a short instructional video immediately prior to solving the same eleven tasks using the simulated TVM. In these eleven tasks, participants had to select tickets for purchase using a simulated ticket vending machine (TVM) of the BVG (Berlin Public Transportation), which was built in Squeak/Smalltalk (see [3] for an introduction) and presented on a 19” touch screen monitor; **Fig. 1** shows three screenshots of that simulated TVM.

The eleven tasks were all realistic (i.e. „Please purchase a single ticket for Berlin ABC, reduced fare“) and differed in difficulty: Without the instructional video, the younger group solved 84% and the older group 52% of them correctly. Fig. 2 shows the frequency of correctly solved tasks in the order they were presented. The necessary domain knowledge (i.e. “What does Berlin **ABC** mean?”) was provided in the instruction (ABC are tariff zones). The experiment lasted about 60-90 minutes, with the task section embedded in questionnaires and interviews.

Fig. 1. Screenshots of the simulated Ticket vending machine

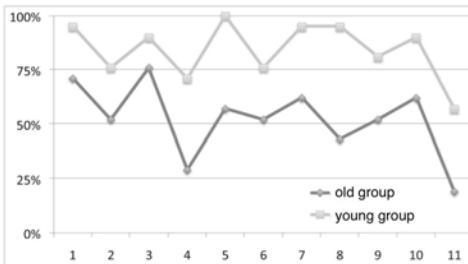

Fig. 2. Frequencies of correctly solved tasks without instructional video (control condition)

In the wizard condition, participants received no video instruction and solved the same eleven tasks using a modified Graphical User Interface that had been designed to require less computer literacy.

Instructional Video. In the brief instructional video (2:37), a narrators voice provided basic interaction knowledge for the use of the ticket vending machine and pointed with his finger to the objects of reference on the graphical user interface (GUI). The GUI resembled the TVM simulation, but to avoid teaching domain as well as interaction knowledge, all ticket button descriptions had been removed. Fig. 3 shows screenshots from the video. The video finished with the same image it had started with so it could be looped. Participants were instructed to touch the screen to stop the video and start with the tasks when they saw fit.

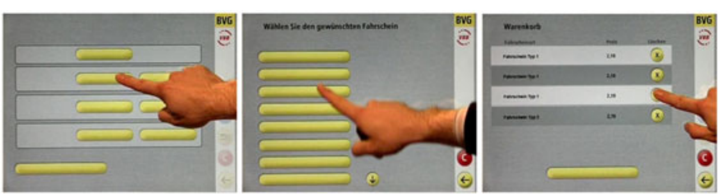

Fig. 3. Screenshots from the brief instructional video

Wizard. In the wizard condition, the TVM-GUI was re-designed to require less computer literacy. For that purpose, the users' task of ticket selection was analyzed and taken as the basis for a wizard design that guides the user through the selection process. The wizard was not meant to humanize the machine, but rather refers to a design pattern that guides the user through complex tasks by decomposing them into a set of manageable steps [4]. There is an immanent trade-off in the use of such a wizard, as we tried to increase the chance of successful interaction (increasing efficacy) by reducing the complexity of screens and providing simple and meaningful choices at the cost of increasing the number of screens and necessary steps and time to solve the task (decreasing efficiency).

This design pattern should benefit older users in particular by reducing cognitive requirements on visual search and working memory, which tend to decrease in old age [5]. Another guideline in the wizard UI-design was to provide goal oriented status feedback in the shape of an actual ticket filling up with choices made and to avoid interaction principles and symbols that might be unknown to older users as much as possible without compromising functionality. Finally, since older and younger users are experts at the task of purchasing a ticket in general (e.g. at the ticket counter) the process of the ticket selection was decomposed into four main questions from the user's perspective: Who wants to go? Where? How long should the ticket last? How many tickets are needed? Fig. 4 illustrates these wizard design elements.

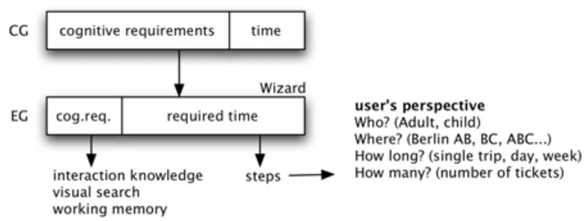

Fig. 4. Wizard design elements

After the wizard had been designed as a paper and pencil prototype [6] it was programmed as a new user interface for the same TVM simulation used in the control and video groups and presented on the same 19" touch screen monitors. Thus, the wizard was built to be functionally equivalent to the original TVM and differed only in the user interface. Fig. 5 shows screenshots from the wizard GUI of the TVM simulation.

Fig. 5. Screenshots from the wizard-GUI of the TVM

2.2 Dependent Variables

The experimental conditions were compared regarding their impact on efficacy, efficiency and satisfaction of the participants. Efficacy was measured as the number of correctly solved tasks, ranging from one to eleven. Efficiency was measured separately as the time and the steps (button clicks) it took to solve a task. Satisfaction was measured as the sum score of 13 items selected from the QUIS [7], asking about the user satisfaction in five applicable fields: general impression (three items), on screen presentation (three items), logical sequence (three items), choice of words (two items) and feedback (two items). All dependent variables were transformed to percent. Consequently, each score of 50% means that a participant had correctly solved half of the tasks, taken twice the time of the best participants and twice the steps necessary, while scoring half of the possible points on the satisfaction questionnaire, respectively.

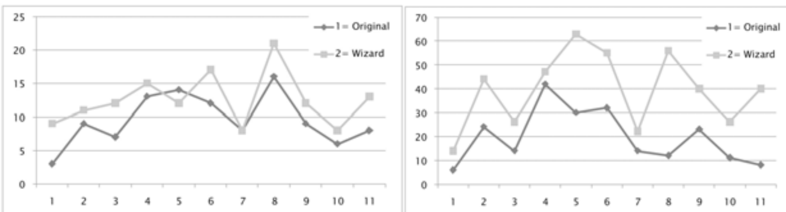

Fig. 6. Number of necessary steps (left) and fastest times (in seconds) to solve the eleven tasks

When comparing efficiency data for the original TVM and the wizard condition one has to keep in mind that they are based on a different minimum of steps and times, as shown in Fig. 6.

3 Results

3.1 Learning through Video Instruction (Manipulation Check)

To find out whether participants had actually learned from the brief video instruction, a knowledge test consisting of seven questions regarding the meaning of buttons that were shown directly on the screen immediately after the experiment (e.g. "What is the meaning of the red button?") was administered as a short interview. Participants who did not watch the video (Mdn = 35.18) already knew most of the correct meanings of buttons, yet those who watched the video (Mdn = 48.99) knew them even more frequently ($U = 574.50$, $p < .01$, $r = -.38$). Hence participants gained TVM specific interaction knowledge through watching the video instruction.

3.2 Computer Literacy and Experience

Since it was hypothesized that participants‘ computer literacy and experience influence their performance using the TVM, the respective differences in the groups were tested. While participants’ computer literacy (CL) and experience (CE) should not differ between experimental and control groups, it was expected that they differ between age groups. To measure CL and CE, the Computer Literacy Scale (CLS) [8] was administered at the beginning of the experiment as a paper and pencil questionnaire. As expected, older participants (Mdn = 34.73) had significantly lower scores on the knowledge part of the CLS ($U = 200.00$, $p < .001$, $r = -.78$) than those in the younger group (Mdn = 90.27). The same is true for computer experience (diversity of use): Older participants (Mdn = 27.73) had significantly lower scores (U = 246.50, p < .001, r = -.69) than those in the younger group (Mdn =69.39).

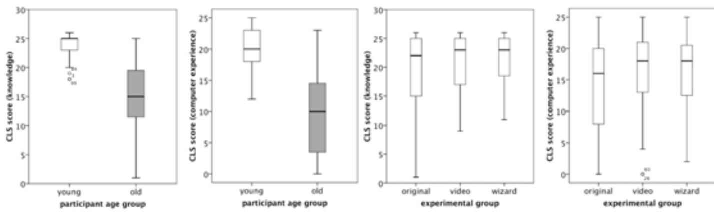

Fig. 7. Computer literacy and experience in the age and experimental groups

Performance differences between the video, wizard and control group should not be attributable to CL and CE, for participants who did not watch the video (Mdn = 60.11) did not differ significantly in computer literacy (H(2) = 1.68, n.s.) from those who watched the video (Mdn = 68.40) or from those who used the wizard (Mdn = 59.05). Again, the same is true for CE: Participants who did not watch the video (Mdn = 46.70) did not differ significantly in computer experience (H(2) = 1.82, n.s.) from those who watched the video (Mdn = 54.29) or from those who used the wizard (Mdn = 55.04). See Fig. 7 for an overview of these results.

3.3 Dependent Variables

Efficacy. The older group benefited from watching the video and even more from using the wizard, while the young group had very high efficacy in all three conditions. A MANOVA revealed a significant main effect of age group on the efficacy of using the TVM, F(1, 118) = 26.92, p < .001, η^2=.19 and a significant main effect of experimental conditions on the efficacy of use, F(2, 118) = 16.93, p < .001, η^2=.23. The Games-Howell post hoc test revealed that efficacy was significantly lower for the control group than for the video group (p<.01) and the wizard group (p<.01), while video and wizard group did not differ significantly. The interaction effect between age group and experimental condition on the efficacy of use was significant, F(2, 118) = 12.67, p < .001, η^2=.19. This indicates that the older group did indeed benefit more from seeing the video or using the wizard. Specifically, participants in the older group who watched the video (M=79.90, Mdn = 18.75) benefited so much that they did not differ significantly in the number of solved tasks (U = 165.00, n.s., r = -.19) from participants in the younger control group (M=86.61, Mdn = 23.14). The same is true for participants in the older group who used the wizard. They benefited so much from the new design that there was no significant difference (U = 209.00, n.s., r = -.00) in efficacy between them (M=89,46, Mdn = 20.59) and the participants in the younger wizard group (M=88.10, Mdn = 21.05). Fig. 8 gives an overview of the results for all six groups.

Efficiency Measured in Time. Both age groups profited from seeing the video in their efficiency measured in time. There was a significant main effect of age group on the efficiency (time) of using the TVM, F(1, 118) = 141.46, p < .001, η^2=.56 and there was a significant main effect of experimental conditions on the efficiency (time) of use, $F(2, 118) = 12.28$, $p < .001$, $\eta^2=.18$. The Games-Howell post hoc test revealed that efficiency (time) was significantly lower for the wizard group than for the video group ($p<.05$) but not for the control group, while video and control group did not differ significantly. The interaction effect between age group and experimental condition on the efficiency (time) was not significant, $F(2, 118) = 0.07$, n.s., $\eta^2=.001$. This indicates that the older group did not benefit more than the younger group from seeing the video or using the wizard. As expected, participants in the older group who watched the video (M=18.48, Mdn = 13.95) still differed significantly in efficiency (time) ($U = 69.00$, $p<.001$, $r = -.57$) from participants in the younger group who did not watch the video (M=34.02, Mdn = 27.71) and participants in the older group who used the wizard (M=22.33, Mdn = 12.67) still differed significantly in efficiency (time) ($U = 35.00$, $p<.001$, $r = -.71$) from participants in the younger wizard group (M=45.77, Mdn = 29.75). This finding is consistent with research showing that the speed of information processing declines with age.

Efficiency Measured in Steps. In efficiency measured in steps, much like with efficacy, even the young group benefited from seeing the brief video and the older group again benefited much more. In the wizard condition, both age groups were equally efficient in steps. There was a significant main effect of age group on the efficiency (steps) of using the TVM, $F(1, 118) = 27.33$, $p < .001$, $\eta^2=.20$ and there was a significant main effect of experimental conditions on the efficiency (steps) of use, $F(2, 118) = 8.17$, $p < .001$, $\eta^2=.13$. The Games-Howell post hoc test revealed that efficiency (steps) was significantly lower for the control group than for the video group ($p<.05$) but not for the wizard group, while video and wizard group did not differ significantly. The interaction effect between age group and experimental condition on the efficiency (steps) was significant, $F(2, 118) = 9.71$, $p < .001$, $\eta^2=.15$. This indicates that the older group did indeed benefit more from seeing the video or using the wizard. In fact, participants in the older group who watched the video (M=59.92, Mdn = 17.65) benefited so much that they did not differ significantly in efficiency (steps) ($U = 143.00$, n.s., $r = -.27$) from participants in the younger group who did not watch the video (M=66.82, Mdn = 24.19). The same is true for participants in the older group using the wizard, who benefited so much that there was no significant difference ($U = 186.00$, n.s., $r = -.10$) in efficiency (steps) between them (M=59.92, Mdn = 19.86) and the participants in the younger wizard group (M=60.38, Mdn = 22.20).

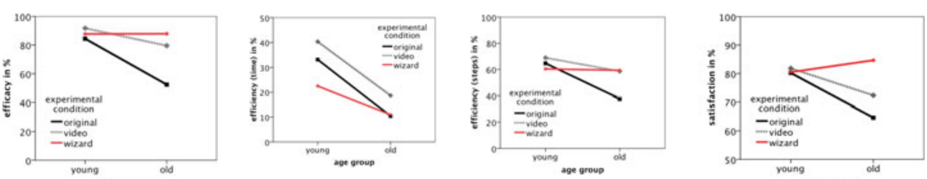

Fig. 8. Efficacy, efficiency (measured in steps and time) and satisfaction in all six groups

Satisfaction. Satisfaction ratings were rather high overall and video had little effect on the users' satisfaction, but particularly for the old group the wizard did. There was a significant main effect of age group on satisfaction with the TVM, $F(1, 118) = 5.26$, $p < .05$, $\eta^2=.05$ and there was a significant main effect of experimental conditions on the satisfaction, $F(2, 118) = 4.41$, $p < .05$, $\eta^2=.07$. The Games-Howell post hoc test revealed that satisfaction was significantly lower for the control group than for the wizard group ($p<.05$) but not for the video group, while video and wizard group did not differ significantly.

The interaction effect between age group and experimental condition on satisfaction was significant, $F(2, 118) = 4.31$, $p < .05$, $\eta^2=.07$. This indicates that the older group did indeed benefit more from seeing the video or using the wizard.

3.4 Summary

Watching a brief instructional video or using a wizard to select the desired ticket proved to be beneficial for both age groups. Specifically, the experimental groups solved more tasks in less time and less steps than the control group and the older group benefited more from the video and the wizard than the younger group in efficacy, efficiency measured in steps and satisfaction. As expected, video and wizard could not close the generation gap in efficiency in time, which largely depends on the decreased speed of information processing (see [9] for an overview of relevant age related changes in cognitive abilities). Also, the video had little effect on user satisfaction, which was a) rather high in all groups and b) based on items about characteristics of the TVM that did not change with the video. However, the wizard had a positive effect on user satisfaction, particularly for the older group.

For practical purposes, the younger generation might not want or need to switch to a wizard or to watch an instructional video for a simple machine as the TVM investigated. However, if the older generation had such a video available to them and actually watched it right before the tasks or switched to the wizard, our findings suggest that they could use the TVM as effectively and efficiently (measured in steps) as the younger generation does without watching the video.

4 Discussion

Both interventions, video and wizard, proved to be suitable approaches to a "universal design", yet they are not equivalent. In particular rarely used "walk up and use systems" in public spaces should be designed so that they can be used spontaneously (without instruction) by anybody, including older adults. Even a simple device like the TVM can pose a challenge for older users. Generally, they have less computer literacy that can guide them in the use and exploration of new technology and since the face of technology changes quickly, generational differences will persist.

However, research shows that for the younger-old many of the age differences in users success can be mitigated by proper instruction and this article has shown specifically, that a brief instructional video presented immediately before the use of a ticket vending machine can eliminate age differences found in efficacy and efficiency of use measured in steps. The advantages of such a brief video are twofold: they are easily produced and they can be integrated into many devices where they can provide help on demand precisely when needed, so the user is ready for the information when he receives it and can practice right in the task he was motivated to do to begin with [10]. For many devices, this concept could also be extended to complete training programs as shown for mobile phones by [11].

Another, perhaps more costly way to compensate for lacking computer literacy is to redesign the interface to require less CL to be used successfully. One way to achieve this goal is to follow a wizard design pattern, which has proven to eliminate age differences found in efficacy and efficiency of use measured in steps as well as or even better than the instructional video. Moreover, the wizard yielded significantly higher satisfaction than the original TVM, particularly for older users. The main advantage of such a wizard lies in the efficacy of its use. While on average the older group was able to select the correct ticket with the original TVM in 53% of the cases, the instructional video increased efficacy to 80% and the wizard even to 89%, which is about the same efficacy the younger group had in all conditions. It can be concluded, that the wizard needed little prior interaction knowledge and was easy enough to be used successfully by all age groups. This effectiveness comes at a price of decreased efficiency. While for the purchase of a single ticket the wizard is still faster than the instructional video plus the original TVM, the knowledge gained in the video can be transferred to future uses, while the knowledge gained through the use of the wizard cannot easily be transferred to the original TVM.

For practical purposes, to support older users it seems appropriate to combine the approaches and their advantages. For rather rarely performed tasks that focus on efficacy rather than efficiency, a wizard design pattern proved to be a good fit. Wizard and instructional video could be integrated into existing machines to provide information and instruction on many levels [6] to be available when and how they are needed.

Two caveats shall be mentioned regarding the generalizability of the findings. First, the investigated TVM can be classified as a "walk-up-and-use-system" that anyone should be able to use without prior training and other, more complex interactive systems (such as project planning software [12]) might pose problems for older users that are not as easily mitigated. Secondly, the video was designed to teach only interaction knowledge, while often it will be of interest to teach domain knowledge as well. Accordingly, the ALISA-project also investigated a comprehensive training environment for the TVM, including the teaching of domain knowledge via video instructions [13]. Further research is also directed at the effect of computer literacy on the successful use of other electronic devices.

Since both interventions proved to be successful, the same concepts were incorporated into a new project in the context of Ambient Assisted Living (AAL) called SMILEY, investigating ways to foster social integration and access to medical and other services through a unified application following two central ideas:

1) Reciprocity: Older adults are receiver and provider of help.
2) Layers of integration: From the apartment to the house and neighborhood and from family and friends to professional service providers.

Based on core themes for desired support extracted from a literature review, such as social isolation, safety and security, forgetfulness etc. [14], results of a requirements analysis for an integrated application and user interface will be presented along with paper and/or working prototypes.

Acknowledgments. This research was funded by the German Research Foundation (DFG) as part of the priority program „age-differentiated work systems“ (SPP1184). We would like to thank all members of the ALISA research project and especially Laura Felten and Marko Peucker who conducted the studies.

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